THE MECHANICAL HANDLING OF MATERIAL

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MECHANICAL HANDLING OF MATERIAL

Being a Treatise on the Handling of Material such as Coal, Ore, Timber, &c. by Automatic or Semi-Automatic Machinery

TOGETHER WITH THE VARIOUS ACCESSORIES USED IN THE MANIPULATION OF SUCH PLANT
ALSO DEALING FULLY WITH THE HANDLING, STORING AND WAREHOUSING OF GRAIN

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With Five Hundred and Fifty Illustrations

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PREFACE.

THE following treatise on the Mechanical Handling of Material has not been the work of a day, a month, or a year. Its origin may be fairly dated back some twenty years ago, when I was professionally engaged in a branch of Engineering which in modern times has been peculiarly identified with the automatic handling of material. I am referring to Grinding of Material in general and Modern Flour Milling in particular. This branch, in which the mechanical handling of material both before and after treatment as well as in its intermediate stages is of the utmost importance, greatly attracted me. I began to make a special study of the different mechanical operations of handling; compiling tables, capacities, and speeds of elevators and conveyors for my own use, as well as such other information as was available. It was my lot to standardise such elevators as were used in flour milling, and the results of my work in this and other directions will be found in this work.

Later on, the field of my professional experience was considerably enlarged, and I found myself engaged in planning and designing installations with appliances for the Mechanical Handling of such raw materials as Ore, Coal, and Timber. Some of the results of my studies in this direction have been embodied in a paper which was read before the Institution of Civil Engineers on the 17th February 1903. The subject was, however, far too large to be exhausted within the limited compass of a paper, and I found, perhaps before I was fully conscious of the fact, that a treatise on a somewhat neglected though vast section of engineering had grown up in my hands. At first, with the diffidence natural to one who had never cultivated literature, I hesitated to put my notes in the form of a book, but these doubts vanished as I realised that no book existed in the English language on this important branch of engineering. Indeed, I have been unable to find a complete and connected treatise on the Mechanical Handling of Material in any language.

Therefore I set to work to reduce my rough notes to the orderly sequence of a formal treatise, embodying in carefully compiled tables a list of the results of my own experience, as well as all other available information respecting the capacities and speeds of machinery designed to handle material in substitution of or supplemental to the labours of human hands. I became a diligent collector of drawings and descriptions of such machinery and mechanical processes as are germane to the subject of this work, and several hundreds of these drawings have been used to illustrate the volume.

I may say that I have made a point of personally studying, wherever possible,

all systems of mechanical handling of material, and have with that view inspected every kind of installation described in these pages. It would, however, have been practically impossible for any one person to personally explore the whole of the immense field which is now covered by the mechanical handling of material. I have, therefore, supplemented my own practical studies and experiences by a careful perusal of all accessible authorities on this subject.

It gives me great pleasure to acknowledge my indebtedness to those authorities I have had occasion to consult. Much valuable information has been obtained from the Proceedings of the Institution of Civil Engineers, and also from the Proceedings of the Institution of Mechanical Engineers. I am further indebted to Mr J. D. Twinberrow, M.I.Mech.E., and to Mr Herbert Stone, M.I.M.E. Professor Buhle's papers in the *Zeitschrift des Vereines deutscher Ingenieure* I have consulted with profit; and am also under obligations to Baron Hanffstengel for his disquisitions on the mechanical handling of ore and coal in *Dingler's Polytechnisches Journal.* I have obtained much useful information on the subject of Tips from the late Sir W. G. Armstrong (Lord Armstrong). Also I must acknowledge my indebtedness to the late Herr Krupp. In the study of the ropeway I have found helpful assistance in the monographs of Mr J. P. Roe, M.I. & S. Inst., and of Mr R. E. Commans, M.Inst.C.E., also of Mr W. T. H. Carrington, M.Inst.C.E. (engineer to Messrs Bullivant), and Mr H. H. Gass, the author of an interesting description of the Anaimalai Ropeway.

I am obliged for the kind and ready permission given me to make use of valuable information derived from the above sources, and should I have inadvertently omitted to acknowledge any source from which information has been obtained, I apologise, and will amend matters should the work be issued in a further edition.

If this book should serve as a guide to the Engineer and Manufacturer, I shall feel that much arduous work, snatched from the active exercise of an exacting profession, has not been spent in vain.

GEORGE FREDERICK ZIMMER.

82 Mark Lane, London, E.C.
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HIGH-LEVEL OR CANTILEVER CRANES.

NOTE.—In addition to the authorities mentioned in the Preface, the Author is also indebted to the following:—

American Engineering and Railroad Journal.
British Refrigeration.
Cassier's Magazine.
Colliery Guardian.
Engineer.
Engineering.
Engineering Times.
Engineering Review (formerly *Feilden's Magazine*).
Iron Age (New York).
Iron and Coal Trades Review.
Iron Trade Review.
Magazine of the Thames Ironworks.
Miller.
Milling.
Page's Magazine.
Proceedings, American Society Naval Architects and Marine Engineers.
Proceedings, Institute of Naval Architects.
Scientific American.
Mr Spencer Miller.
Stahl und Eisen.
Conservation des Grains par l'Ensilage.
Timber Trades Journal.
Essays on the Floating Matter of the Air.
Zeitschrift des Vereines deutscher Ingenieure.

THE MECHANICAL HANDLING OF MATERIAL.

CHAPTER I.

INTRODUCTORY.

THE application of machinery to both the handling and conveying of heavy and bulky material has of late years assumed a paramount interest. No branch of engineering has so rapidly developed in modern times as the construction of appliances for loading and unloading heavy goods, more particularly coal and ore. In the case of grain and seeds again the construction of granaries and silo-houses on a large scale has been undertaken, and the aid of automatic machinery more or less sought to provide means of handling this material as far as possible without the assistance of hand labour. The increased competition met with in all branches of manufacture has forced upon capitalists the necessity of economising in every department. The exaggerated importance attached by the followers of Ruskin to hand labour has passed into the region of obsolete and unworkable theories, and labour-saving appliances are everywhere regarded as being absolutely essential to the progress of all industries.

The mechanical handling of grain is of prior date, but it was not till comparatively recent years that the engineer was able to render any effective assistance in the handling and automatic conveying of coal and ore. It was not until towards the latter end of the nineteenth century that the growing demands of industry made it imperatively necessary to store coal on a large scale, and so brought about this mechanical revolution. This movement received greater impetus from the many electrical power stations and extensions of gas-works which have marked the industrial history of the past twenty years.

The loading and unloading of bulk cargoes in and out of vessels and railway trucks used to be effected entirely by hand.

In some of the harbours and docks of Africa, India, South America, in the West India Islands, and also in the Far East, this process is still sometimes in vogue for loading vessels, or has been within the past few years. This primitive mode of handling material is, however, disappearing to make room for mechanical appliances.

The annexed illustration depicts such an instance during the Russian and Japanese War, and shows the coaling of a battleship at Nagasaki, the "Portsmouth" of Japan.

Gangs of 50 to 150 natives, both men and women, used to carry the coal, &c., in

baskets on their heads to and from the ships, the result of their toil being about 3 to 4 tons of coal per carrier per day.

In some ports, New Orleans and St Louis amongst others, the use of wheelbarrows was the first step in the right direction, and superseded the last-mentioned process. The gangs with wheelbarrows consisted of about twenty men, and they delivered on the average 6 tons per man per day. The next step was the adoption of narrow-gauge lines with hand trucks, which raised and delivered 10 tons per man per day. By substituting self-unloading trucks for ordinary hand trucks, the capacity per man was raised to 12 tons per day. But even this improvement gives a far from satisfactory result. The process is too slow, and therefore too expensive, and is also subject to strikes and other interruptions. It was not until a few years ago that satisfactory appliances were introduced.

In addition to these considerations, there remains the great difficulty, if not impossibility, of handling the annually increasing quantities to be dealt with without the aid of machinery.

Hand labour was good enough in the days when, according to the earliest records, the first coal was shipped from Newcastle in 1226, and landed at Jacob's Lane, in the Fleet, in London; but since then great changes have taken place.

In 1849 the annual production of coal in this country was 107,427,500 tons, of which 13,053,000 tons were exported as cargo or used for steam navigation. The import of sea-borne coal into London is but a small proportion of the coal handled in the principal coal-ports of this country. In 1899 the production was 220,085,000 tons, and the export 55,335,370 tons; while in 1902 the coal production was 227,095,042 tons, of which 44,897,948 tons was exported as cargo and used for steam navigation. Besides coal, an immense bulk of other minerals is handled year by year. As far as can be ascertained, the present annual mineral production of the United Kingdom amounts to 287,159,612 tons of raw material, this immense tonnage being made up as follows:—

	Tons.
Coal	227,095,042
Iron ore *	13,426,217
Limestone and chalk	16,568,524
Clay	15,304,136
Sandstone	5,483,130
Salt, granite, sand, gravel	9,282,563
Total	287,159,612

It is obvious that such quantities can only be economically handled by mechanical means.

The quantities given for export coal are by no means the total quantity loaded and unloaded, as all the sea-borne coal that remains in the country and is only shipped from port to port must be added; whilst the former has only to be handled once at the dock, the latter may have to be handled twice or thrice. In addition to the coal shipped, there is a large bulk which is carried by rail, and should be more or less mechanically loaded or unloaded into or from trucks.

Not only have these large quantities of coal to be handled in the course of each year between ships, barges, trucks, and coal stores, but the immense bulk of our grain and seed imports must be dealt with in a similar manner.

According to the Board of Trade statistics, Great Britain consumes annually 17,051,428 tons of cereals, and as the home production only amounts to 6,051,428 tons per annum, the balance of 11,000,000 tons † has to be imported. In addition to this, we import annually 675,029 tons of seeds, principally for the extraction of oil. This gives the respectable total of 17,726,457 tons of grain and seeds to be handled per annum, and this quantity is by no means a fixture, but grows annually to greater dimensions.

The bulk of the imported cargoes of grain and seeds is carried in large ocean-going steamers for which there is only accommodation in our principal ports. The grain, therefore, is in many instances unloaded from the large vessel into smaller ones which can enter the rivers and canals and deliver the grain to its final destination. This means that the bulk of these cargoes of grain has to be handled twice over.

In the introduction of machinery for the automatic handling of such material America no doubt took the lead, a step which was largely due to the peculiar con-

* This includes a small quantity of imported ore.

† This includes 1,000,000 tons imported in the form of flour and meal.

ditions of that country, where a saving of labour was at that time perhaps more important than in Europe. It must be admitted, however, that in this country and on the Continent the lead taken by America was quickly followed up, and both here and abroad American means of mechanically handling such goods have been more or less followed.

In round figures it may be taken that the saving of one man's wages warrants the investment of £1,000 in machinery; hence in his quest for economy the engineer is ever on the alert to reduce the wages bill, and handle everything automatically.

The modern flour mill may be cited as an example of automatic handling. So perfect is its automatic character that wheat may be unloaded from an ocean-going steamer, stored, cleaned, graded, ground, dressed, packed, weighed, registered, and delivered into a railway truck for despatch to the consumer without any manual labour whatever. The consequence is that, whereas a few years ago it would have required twenty to thirty men to produce a given quantity of flour, the same result may now be effected by three or four, who are simply employed in adjusting, cleaning, and lubricating the machinery.

It would be rash to assume that the multiplication of mechanical appliances is detrimental to the interests of the worker. On the contrary, experience has shown that his daily life is thereby made easier, his intelligence improved, and his wage-earning capacity increased.

In the construction of machinery for the mechanical handling of material, local conditions have necessarily to be largely taken into consideration.

A review seriatim may be taken of the various appliances which have been devised for the conveying and handling of grain, coal, ore, and coke. Coal, which is not only a raw material of prime necessity in almost every branch of industry, but is also a material of considerable intrinsic value—a value which is subject to rapid and sensible depreciation from rough handling—deserves the first place, as no doubt it has been the subject of more careful thought on the part of engineers than almost any other heavy material.

It may, however, be observed that the same means of automatically conveying and of handling coal are very generally applicable to other heavy substances, such as ores and coke, though no doubt the special nature of the material to be handled must always be taken into account.

The loading of ships with coal is a comparatively simple matter. The railway trucks containing the coal may either be lifted and their contents then shot, or they may be tipped from the quay-side, or the coal may be discharged by self-emptying railway trucks. The main point is this, that the coal is allowed to discharge itself by its own weight into a shoot which conveys it into the ship's hold. To prevent depreciation by rough handling, many ingenious forms of discharging apparatus have been invented which are one and all intended to reduce or break the fall of the material, thus bringing it into the hold of the barge or vessel in as whole and sound a condition as possible. In order to save trimming in the hold, ships have been specially built with a great number of hatchways, but as yet no satisfactory appliance has been found which will trim coal mechanically in the hold of an ordinary ship.

An important subject is the service of large boiler-houses and gas-works. Here mechanical means are used for filling and discharging bunkers, bins, or silos, and two essential features in such installations are the automatic feeding of the boilers and retorts, and the removal of the ashes and coke.

Much attention has also been devoted to the coaling of railway engines and the feeding of blast furnaces.

The subject as a whole is a very extensive one, and is here divided into—

Appliances and installations which deal with the material CONTINUOUSLY—that is, receive and deliver it in an uninterrupted stream—such plant, for instance, as is suitable for factory yards, coal and other mines, gas-works and power stations, &c.

Such installations as serve to handle material INTERMITTENTLY and for longer distances, as light railways and ropeways in conjunction with grabs and other unloading devices.

A number of complete installations in which these appliances are used are illustrated and described in the course of this work.

In dealing with machines of the continuous type it will be evident that the material which is being handled is evenly distributed over the entire length of the elevator or conveyor; thus the apparatus is only burdened with a comparatively moderate weight, a fact which permits of a relatively light construction of the mechanism throughout. For this reason appliances of this type have often a distinct advantage over machines which must lift a considerable load at one point, because in the latter case the load, consisting of the material under treatment and the receptacle in which it is being carried, is concentrated in one place, and necessarily requires machinery of a heavy description and of very solid construction. Again, in what may be termed the intermittent conveying of material, as for instance in the use of cranes, there is the operation of charging and discharging, to say nothing of the loss of time, sometimes unavoidable, from the return of the empty receptacle, whereas there is no loss of the kind with machinery of the continuous type. The capacity of a crane is really limited, because its speed is not capable of any considerable increase, on account of the heavy weight to be dealt with.

To greatly increase the load carried at each lift is often impracticable, because the bucket or skip becomes more awkward to handle, and smart brisk work is then out of the question, whereas with a continuous conveyor it is perfectly possible to quadruple the capacity by simply increasing the width of the conveyor, always of course provided that the feed of the material being handled keeps pace with the increased capacity of the conveyor.

When it is a case of handling large and heavy lumps, cranes are undoubtedly in place, especially where it is a question of quickly clearing barges or railway trucks.

Most important factors in the choice of machinery for given purposes are general local conditions and the adaptation of the machinery to the space available.

The material should be handled as gently as possible if it be liable to deteriorate through breakage, as in the case of coal, which may easily lose from 5 to 10 per cent. of its value through rough handling, and this consideration is even more urgent in the case of coke, as coke dust is almost worthless.

To minimise the cost of upkeep, as the constant renewal of parts of the machinery will form in some installations a considerable addition to the working expenses, all parts of the machines which are liable to accident, from at times unavoidable rough handling, should be capable of being promptly and easily replaced.

The installation should be as free from liability to accidents as it is possible to attain, as human lives and valuable property may be lost by accidents and breakdowns, and last but not least, even a temporary stoppage of the works may cause serious loss.

The Continuous Handling of Material.—The subject of handling material continuously may be classified under three heads:—

1. APPLIANCES FOR LIFTING IN A VERTICAL DIRECTION, OR FROM ONE LEVEL TO ANOTHER, COMMONLY CALLED ELEVATORS.

2. Appliances for Moving Material in a Horizontal Direction, commonly called Conveyors.

3. Appliances which combine the two former objects by Elevating and Conveying the Material horizontally at the same time.

In the succeeding pages the older conveying appliances employed for these purposes are briefly described, more space being devoted to those which have recently been introduced.

Conveyors are subdivided—

Firstly, into appliances consisting of a fixed trough in which the material is conveyed by means of some pushing agent;

Secondly, into appliances in which the trough containing the material moves bodily and with the material; and

Thirdly, into appliances in which the trough conveys the material by its own reciprocating motion.

CONTINUOUS HANDLING OF MATERIAL.

CHAPTER II.

ELEVATORS.

ELEVATORS in a primitive form have been known and used for a very considerable time, and since their introduction have undergone little alteration except in detail. The term elevator is usually applied to endless belts or chains to which are attached a series of suitably shaped receptacles or buckets. These chains or belts run over two terminal pulleys which are fixed at different levels, the distance from centre to centre of these pulleys being called the length of the elevator.

Elevators are designed to suit special purposes. For instance, grain elevators are always encased in wooden or iron trunks, the head and foot being also of wood or iron. The position of the elevator trunk in this case is nearly always vertical. The support for the bucket consists either of leather belting, cotton belting, hemp webbing, or indiarubber with insertion. For minerals—coal, coke, cement clinker, and other heavy materials—elevators are usually fitted with sprocket wheels and chains which support the buckets. The elevator in the latter case is generally in a slanting position. The buckets are attached to the links of the chain and an intermediate short skidder bar is employed which slides on well-oiled angle bars on each side. This prevents the bucket and chain from sagging. Both grain and mineral elevators are generally furnished with tightening gears to keep the belt or chain taut.

Tightening gears for elevators are generally arranged at the lower or well end of the elevator, because if placed at the top or delivery end the tightening of the chain or band often disturbs the driving arrangements. The ordinary tightening gear at the elevator well has this disadvantage, that the space between the bottom of the well and the bucket must vary. Where grain elevators are concerned this is of less consequence, but in elevators handling coal, minerals, and other material of varying size it is desirable to keep an even space between the buckets and the bottom of the well, as shown in Fig. 7. In this case the elevator well is designed to go down with a sprocket wheel when the chain is tightened, and *vice versa*, whilst the bracket supporting the elevator well remains a fixture.

There is a third way of tightening elevators without interfering with either the feed or the delivery end, and this is by means of a separate tightening or jockey pulley, arranged at some convenient point on their length, in a similar manner to the pulley shown in Fig. 7 (although in this particular instance the pulley is for another purpose).

As a rule, especially with grain elevators, the tightening gear is made together with the elevator well; but for larger elevators, particularly those which are used for heavy material, the tightening gear is separately mounted on the supporting girders of the elevator framing.

Figs. 1 and 2 show two such tightening gears. Both have an adjustment which will allow of holding the bearing in position after tightening. The construction is so simple

that it explains itself. The gear shown in Fig. 1 allows of an adjustment to suit elevators at a variety of inclines. See also Tightening Gears, page 90.

To prevent choking of the feed of elevators the buckets should be made large enough to cope readily with the feed, and at the same time due allowance must be made for the largest pieces to be elevated. In addition to the above, the elevator must be fed correctly. For instance, if fed from a large accumulation of material, say from a stock heap or from a bin, it would not do to feed the elevator by an ordinary spout.

In such a case the elevator should preferably be fed from an oscillating feed shoot, making between 30 and 60 oscillations per minute, which deposits at each backward and forward stroke a quantity corresponding to the capacity of the elevator. This precaution is, however, only necessary when dealing with minerals of uneven size (see Feeding Devices, page 21), and would not be necessary when handling grain or seeds. The choking in such cases, if ordinary spouts are used, is due to one of two causes. Either the rush of feed is too great, and is therefore more than the elevator can take up, or else a few large pieces of foreign material have found their way to just above the feed spout and arch it over, thus stopping the feed altogether. Feeding devices will obviate

Fig. 1. Adjustable Tightening Gear for an Inclined Elevator.

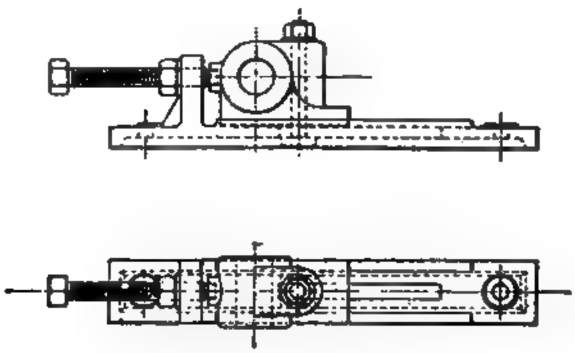


Fig. 2. Elevator Tightening Gear.

both. They will not allow an undue rush of feed, and prevent the arching over by keeping the material constantly in motion. The same remarks apply, not only to elevators which are fed from large hoppers, but also to smaller hoppers which are fed intermittently by grabs, or which receive at intervals the contents of trucks or railway waggons.

The elevator should always be fed from that side on which the buckets ascend, so that the stream of material runs into the elevator buckets meeting them on their upward journey. This will prevent the material from falling into the elevator well, and does not necessitate the buckets dredging through an accumulation of feed. If elevators are erected at an incline, it is advisable, where possible, to feed them at a point several feet above the well into the upgoing strand, as in this case very little will miss the buckets and drop into the well.

For elevators of very large capacity two or more strands of chain are sometimes used to support the buckets, but there is a drawback to the employment of multiple strands when using ordinary malleable iron chains, as the different strands are apt to stretch unevenly and throw the buckets out of parallel with each other. It is therefore always best, when possible, to use one chain of sufficient strength, or chains with double links, that is, two links cast together with a web in the middle. These remarks refer

only to ordinary malleable-iron chains, and not to malleable-iron or wrought-iron link chains, which are jointed together by steel bolts through bored holes. This kind of chain is always used for elevators of large capacities and for heavy materials, such as coal, and runs over polygon or sprocket wheels.

Position of Elevators and their Speed of Running.—The reason why an elevator should sometimes be vertical and sometimes set in an inclined direction is this, that in elevating materials of low specific gravity an elevator can be driven at a much higher speed than the elevator which is handling material of higher specific gravity, as a velocity of the material at the delivery which would not injure grain would break up coal and other heavier and friable products. Moreover, the receiving spouts and shoots would be quickly destroyed by the impact of the material. Elevators in a vertical position are therefore only suitable for specifically light material, and can be run at a circumferential velocity of 250 to 350 feet per minute. Elevators for heavy material must be either wholly or partially inclined, to give a clean delivery without scattering at the much lower speed of 50 to 160 feet per minute. It is for this reason that elevators for specifically heavy material require so much larger buckets, chains, &c., than say grain elevators of the same bulk capacity.

There is a second reason why it is essential to run an elevator for heavy material up an incline, namely, the fact that it is more easily driven; for part of the load is then borne by the inclined supports instead of the whole weight hanging from the driving gear, as in the vertical elevator. The angle at which to fix an elevator in order to get the most favourable results, without occupying too much space, is 45 to 60 degrees to the horizon.

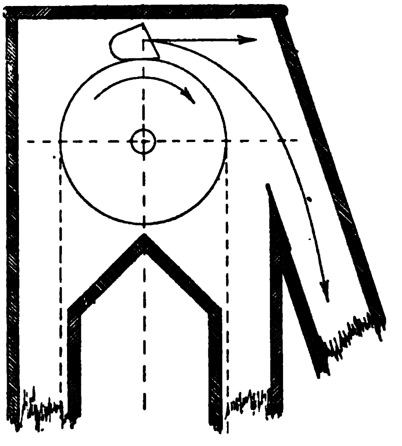


Fig. 3. Diagram showing Discharge of Elevator Bucket.

The speed of elevators which are fixed in a perpendicular position for dealing with grain, &c., depends upon the diameter of the elevator pulley, *i.e.*, the pulley on which the band which carries the buckets is running, because such an elevator, in order to deliver perfectly, must throw the grain a certain distance, which is equal to the radius of the pulley plus about 1 foot, in order to clear the preceding buckets and to reach the discharge spout. The elevator buckets generally begin to discharge when in the highest position on top of the pulley. To effect perfect discharge the centrifugal force must be sufficient to overcome the gravity of the material, so that for a specifically heavy material it is necessary to have a greater centrifugal force, *i.é.*, higher speed of elevator than for a specifically lighter material, as no matter with what velocity a body may be thrown off tangentially from the elevator pulley, the moment it is free from its support the attraction of the earth asserts itself and causes the body to eventually fall upon the earth. If the direction of the material is horizontal, as is the case in the delivery from a vertical elevator, the attraction of the earth causes the body to move in a parabolic curve, and the heavier the body, the more will its path deviate from the horizontal at every instance (see Fig. 3).

A light body at a given linear velocity will proceed in an approximately horizontal line for a longer distance than a heavy body, as the earth's attraction is more or less counteracted by the friction of the atmosphere.

The centrifugal force of pulleys revolving at the same speed is in direct proportion to the diameter of the pulleys. For example, in a 1-foot pulley it will be twice what it is in a pulley 2 feet in diameter running at the same speed; when the speed of an elevator pulley of a given diameter is increased, the centrifugal force increases in proportion to the square of its velocity; consequently the centrifugal force of a pulley 2 feet in diameter running at 50 revolutions per minute will be four times the centrifugal force of a pulley of the same diameter running at only 25 revolutions per minute. This indicates clearly that in the case of grain elevators it is quite inaccurate to estimate the number of revolutions of the elevator pulley by a fixed belt speed for pulleys of all sizes, which is a mode of calculation too frequently adopted.

Speed and Capacity of Grain Elevators.

Diameter of Pulley.	Width of Pulley.	Size of Buckets.	Pitch of Buckets.	Revolutions per Minute.	Speed of Belt per Minute in Feet.	Capacity in Tons or Bushels per Minute.
Inches.	Inches.	Inches.	Inches.			Tons or Bushels.
18	11	9×4	17	58 to 62	280	13½ or 500
21	13	11×4	17	52 „ 56	300	27 „ 1,000
24	15	13×5	18	48 „ 52	310	40 „ 1,500
27	17	15×5	18	44 „ 48	320	45 „ 2,000
30	19	17×5	18	40 „ 44	330	70 „ 2,500
33	21	19×6	19	38 „ 42	340	81 „ 3,000
36	23	21×6	19	36 „ 40	350	95 „ 3,500
42	25	23×7	20	32 „ 34	360	108 „ 4,000
48	26	24×8	21	31 „ 33	400	140 „ 5,000
60	26	24×8	21	31 „ 33	500	170 „ 6,250
72	26	24×8	21	31 „ 33	600	203 „ 7,500

Speeds and capacities of elevators of different sizes for grain are given in the above table.

The largest grain elevator in the United Kingdom is that at the Manchester end of the Manchester Ship Canal, which has a lifting capacity of 350 tons per hour.

The following table of capacities of elevators running at different speeds was given by Mr P. W. Britton in his paper on the "Transport and Storage of Grain,"* the buckets being 12 inches apart.

Size of Buckets.	Number of Bushels raised per Hour.		
	Speed = 200 Feet per Minute.	Speed = 300 Feet per Minute.	Speed = 500 Feet per Minute.
6 inches by 4 inches - - -	275	412	687
8 „ 5 „ - - - -	600	900	687
10 „ 5½ „ - - - -	850	1,275	2,125
12 „ 6 „ - - - -	1,300	1,950	3,250
14 „ 6 „ - - - -	1,600	2,400	4,000
20 „ 6 „ - - - -	2,275	3,412	5,687

* See Proceedings Inst. C.E., vol. cxxvi., 1895-96.

If placed at any further distance apart, the capacity would diminish in direct proportion, so that with elevator buckets spaced 2 feet apart, the capacity of the respective elevators would only be half that given in the table.

Unless buckets are of special construction, such as those shown in Fig. 8, it is advisable to keep a space between them not less than that occupied by one bucket, so that an elevator thus fitted with ordinary buckets would be of half the capacity of that of the elevator shown in Fig. 8, provided the buckets themselves were in both cases of the same capacity.

In cases where it is necessary to employ large top terminal pulleys (3 feet and over) in order to obtain delivery of a desired quantity in a given time, the bottom terminal pulley may be of considerably smaller size, in which case the legs are at an angle with the axis of the pulleys. Fig. 4 illustrates the usual form of grain elevator.

As regards data for mineral elevators, it is exceedingly difficult to tabulate such information, as the speed and consequently the capacity of such elevators vary greatly with the nature of the material to be elevated, whether hard, tough, or friable. While it is usual to run coal elevators 90 to 130 feet per minute, according to the friability of the coal, coke elevators run only at 50 to 90 feet per minute; while, on the other hand, minerals which do not deteriorate through breakage may be elevated at the rate of 120 to 160 feet per minute.

The capacity of such elevators depends of course on the speed of travel and on the size and pitch of the buckets. The following table gives a few particulars of the speed and capacity of coal elevators:—

Width of Buckets.	Pitch.	Speed of Travel.	Delivery.
Inches.	Inches.	Feet per Minute.	Tons per Hour.
12	18	120	20
18	18	120	30
24	18	120	40

Figs. 5 and 6 show the most common form of mineral elevator, Fig. 5 representing the top and Fig. 6 the lower part of the same elevator, whilst Fig. 7 shows a form often adopted when the nature of the material prevents it being discharged readily out of the buckets, or where local conditions, such as want of space, &c., make it necessary to fix the elevator at a steeper incline than 60 degrees. It is apparent that such an elevator as is shown in Fig. 7 must have double strands of chain placed on either side of the buckets, so that the guide wheels which curve the chain may not foul the buckets. Similar elevators are, however, made with single strands of chain with skidder bars which slide round two angle-bar curves instead of the guide pulleys. This is, however, only advisable in small installations.

A very economical form of elevator is one fitted with a continuous chain of buckets. This kind is naturally of a much larger capacity than an ordinary elevator of the same dimensions. It takes and delivers its load with more uniformity, and as the buckets need not plough intermittently through the contents of the elevator well, smoother running is secured. Fig. 8 shows such an elevator for grain, and Fig. 9 for minerals.

The table below gives dimensions of continuous elevator buckets for grain and their capacities in tons per hour at varying speeds:—

Width of Bucket.	Projections of Bucket.	Speed of Elevator Belt in Feet per Minute.								
		250	300	350	400	450	500	550	600	650
Inches.	Inches.									
	4	10	12	14	16	18	20	22	24	26
4	5	15	17	19	21	23	25	27	29	31
	6	20	22	24	26	28	30	32	34	36
	4	15	18	21	24	27	30	33	36	39
6	5	22½	25½	28½	31½	34½	37½	40½	43½	46½
	6	30	33	36	39	42	45	48	51	54
	4	20	24	28	32	36	40	44	48	52
8	5	30	34	38	42	46	50	54	58	62
	6	40	44	48	52	56	60	64	68	72
	4	25	30	35	40	45	50	55	60	65
10	5	37½	42½	47½	52½	57½	62½	67½	72½	77½
	6	50	55	60	65	70	75	80	85	90
	4	30	36	42	48	54	60	66	72	78
12	5	45	51	57	63	69	75	81	87	93
	6	60	66	72	78	84	90	96	102	108
	4	45	54	63	72	81	90	99	108	117
18	5	67½	76½	85½	94½	103½	112½	121½	130½	139½
	6	90	99	108	117	126	135	144	153	162
	4	60	72	84	96	108	120	132	144	156
24	5	90	102	114	126	138	150	162	174	186
	6	120	132	144	156	168	180	192	204	216
	4	75	90	105	120	135	150	165	180	195
30	5	112½	127½	141½	157½	172½	187½	202½	217½	232½
	6	150	165	180	195	210	225	240	255	270

Elevators for Flour and Provender Mills.—Although elevators used in flour mills are generally of small dimensions, they are in universal use, and most automatic flour mills have from ten to twenty or more elevators constantly at work. It may be as well, therefore, to describe them in their broad details, especially as these general remarks will to some extent apply to other kinds of elevators.

The spindle driving the pulley at the elevator top should be sufficiently strong to support the weight of the elevator itself as well as the load to be conveyed; the pulley and spindle at the elevator foot are merely guides to keep the belt taut and in the proper position. The elevator foot should, if possible, be fed at a point not lower than the centre of the pulley, while the discharge at the elevator top should be as low as possible, but not higher than the level of the under side of the internal pulley. If the delivery spout be placed higher than this, some of the material will miss the spout and drop into the elevator well, causing a draught of air and an overloading of the elevator, with consequent loss of power, as in such a case a proportion of the material will be carried

round and round. The draught of air caused by the particles falling into the elevator well is perhaps of small consequence when dealing with whole grain, but when elevating flour or finer light material this draught of air is most objectionable, as the dust blows out through all the crevices of the elevator casing, and if any door in the elevator is opened a regular blast of dust will issue from the opening. If, however, the discharge pipe be placed about level with, or better, a few inches below the under side of the pulley, the discharge will be a perfect one, provided the elevator is running at the correct speed.

Usually the elevator is cased in a wooden box or pair of boxes or trunks which enclose the elevator legs. Plenty of space must be allowed in order to obviate any

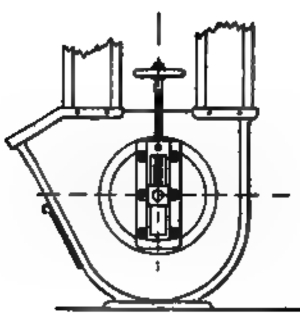


Fig. 4. Usual Form of Grain Elevator.

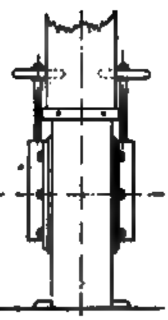


Fig. 5. Top of Mineral Elevator.

possibility of the buckets touching the trunk; and further, if the buckets are fitting too close, they are also apt to act as a fan and create dust.

The elevator top which covers the pulley, and which also carries the bearings for the top spindle, may be made either of wood or iron. For ordinary use in flour mills wood is preferable, as it is easier to attach to the woodwork of the roof or the floor of the building. Iron elevator tops are used in cases where the trunking is also made of iron, in order that it may be fireproof. This particularly applies to the wheat-cleaning department, to provender mills or to fireproof factory buildings.

The following table gives speeds of different sizes of elevators based upon the diameters of the internal pulleys:—

Diameters of Pulleys. Inches.	Revolutions per Minute.
9	80
12	75
15	60
18	55
21	50
24	45
27	40
30	35

These are the speeds of elevators used in flour mills which handle all kinds of products manufactured in the flour-milling process.

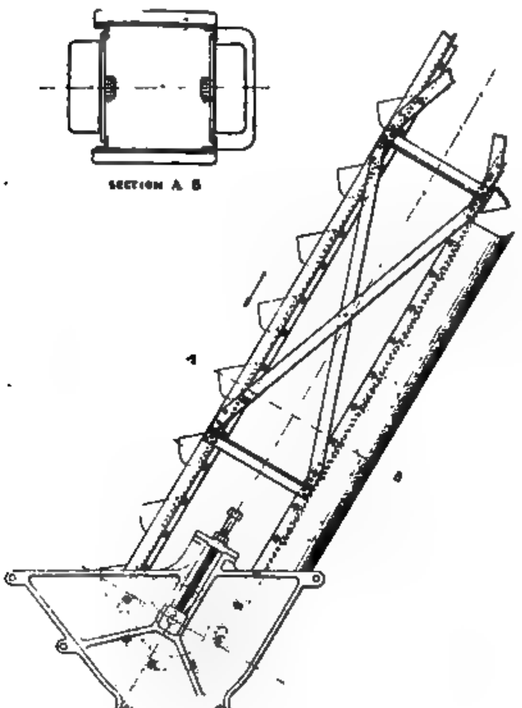


Fig. 6. Well of Mineral Elevator.

Fig. 7. Special Form of Elevator.

The dimensions of the elevator trunk should be such that a space of 1½ to 2 inches be left clear between the buckets and the trunk. The buckets often met with in older flour mills are of such a shape as to make a proper discharge of their contents well nigh impossible.

It is advisable to vary the shape of the buckets for the different products they have to handle. A shallow bucket is best for soft and clinging material such as flour, whilst for harder material, such as wheat, middlings, &c., a deeper bucket will be found preferable.

Figs. 10 and 11 show two elevator buckets, the former for soft material, and the latter for more granular material. The former will be found to fill easily and discharge freely such material as flour, rolled middlings, dunst* and fine offals. A bucket such as is shown in Fig. 11, if used for soft material, would in many cases not fill completely, but would only allow a heap of stuff to rest on the top, leaving a hollow in the lower portion of the bucket; on ascending, the material at the top frequently drops down to the bottom of the bucket, and when it reaches the discharge spout it will not empty in time to fall into the discharge shoot; consequently some of its load will miss the spout and fall down the elevator trunk. The bucket should be made of sheet iron or steel, and may be manufactured in the ordinary way, namely, stamped out in one piece. It is not advisable to have buckets made of raw hide, as used to be the practice, as they are rough

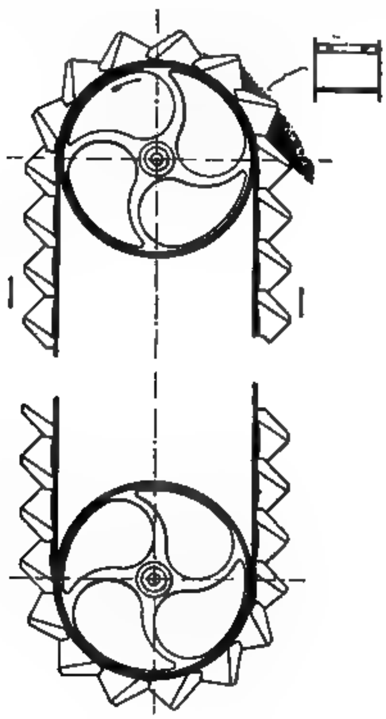


Fig. 8. Continuous Bucket Elevator for Grain.

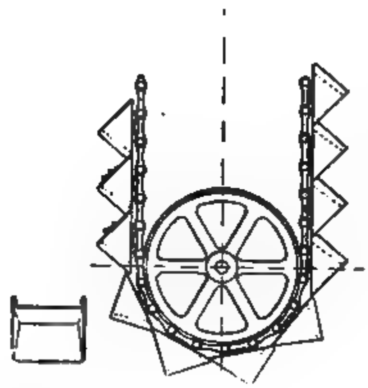


Fig. 9. Continuous Bucket Elevator for Minerals.

and do not deliver the material they carry as well as one made of iron with a smooth surface. Buckets should not have a wire-soldered rim, nor yet rivets or any such pieces as may by wear and tear become detached and cause considerable damage should they enter the silk-covered dressing machines in a flour mill. The attachment of the buckets to the elevator band is best effected by bolts with mushroom-shaped heads. Clips, which were formerly used for this purpose, lack strength and are liable to break.

In the bucket shown in Fig. 10, the angles *abc* should be at 45, 90, and 45 degrees respectively; whilst in Fig. 11 they should be 60, 90, and 30 degrees.

In selecting an elevator it is well to allow a liberal margin in its capacity, for if the spout should choke for only a little while, as soon as it is cleared an accumulation of stuff

* The finest middlings.

will rush to the elevator and again choke it, which is a serious matter in an automatic mill, as one link of the chain, if disorganised, will disconnect all succeeding links.

In the following table will be found suitable sizes for flour-mill elevators, with other useful information :—

No.	Diameter of Pulley.	Width.	Revolutions per Minute.	Bucket.			Pitch of Bucket.	Capacity in Bushels per Hour.
				A. Length.	B. Width.	C. Depth.		
	Inches.	Inches.		Inches.	Inches.	Inches.	Inches.	
1	9	5	80	3½	2½	2	12	25
2	12	6	75	4½	3	2½	12	40
3	15	7	60	5½	3½	3	15	90
4	18	8	55	6½	4	3½	15	145
5	21	9	50	7½	4½	4	18	200
6	24	10	45	8½	5	4½	18	400

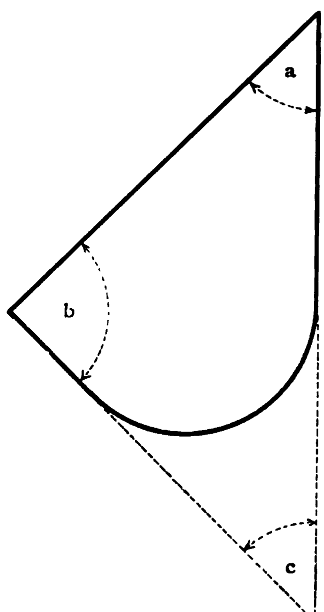


Fig. 10. Bucket for Soft Material.

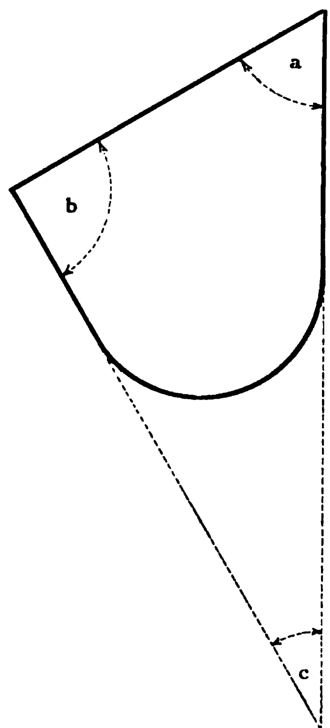


Fig. 11. Bucket for Granular Material.

As the different products in a flour mill vary greatly in specific gravity, a further table is appended in which is given in hundredweights the capacity of different sized elevators when working on different products.

The numbers of elevators given in the top row correspond with the dimensions and particulars given in the previous table. The last six lines of the table refer to the

products of the breaks of a flour mill, and the weights are based on a sample of wheat weighing 60 lbs. to the bushel. Different break products are marked 1, 2, 3, 4, 5, 6, and refer to the break meal as it comes from the break roller mills and enters the elevators. The weights of the various materials per bushel have been carefully taken by the author, and can be accepted as reliable.

CAPACITY OF ELEVATORS, WITH VARIOUS PRODUCTS, IN HUNDREDWEIGHTS PER HOUR.

Size of Elevator.	1	2	3	4	5	6
Wheat - - - - - -	15	24	54	87	120	240
Barley - - - - -	12	20	45	72	100	200
Oats - - - - - - -	10	16	36	58	80	160
Maize - - - - - -	15	24	54	87	120	240
Malt - - - - - - -	10	16	36	58	80	160
Beans or peas - - - - -	16	26	58	94	130	260
Wheat meal or barley meal -	10	16	36	58	80	160
Oatmeal - - - - - -	19	15	34	55	76	152
Semolina - - - - - -	12	20	45	72	100	200
Middlings - - - - - -	11	18	40	65	90	180
Flour - - - - - -	14	22	50	81	112	224
Fine pollard (or sharps) - -	5	7	16	26	36	72
Coarse pollard (or sharps) -	14	6	14	22	31	61
Chop - - - - - -	12	19	42	68	95	190
Bran - - - - - -	3	5	11	17	24	48
First break - - - - -	15	24	53	92	118	236
Second break - - - - -	11	18	40	65	90	180
Third break - - - - -	9	14	31	51	70	140
Fourth break - - - - -	6	9	20	32	44	88
Fifth break - - - - -	5	7	16	26	36	72
Sixth break - - - - -	4	6	14	22	36	62

In the preceding tables the speeds given for different elevators are good average speeds and perfectly accurate when applied to most materials in a flour mill. When treating semolina and other comparatively heavy and granular materials, as well as in the handling of wheat, an increase of 10 per cent. is admissible; while on the other hand, with flour and very fine material, a reduction of 10 per cent. on the speeds is to be recommended.

All elevators will work fairly well at a small margin on either side of the correct speed. Elevators handling material of a lighter nature should not have the buckets as close together as in the case of heavy material, if running at the same speed.

In elevators for soft material the delivery spout should also be placed at a lower point, as the lighter material is necessarily slower in clearing the buckets, and with buckets too close together a portion of the material will fall on to the back of the preceding bucket instead of passing into the outlet spout. This is especiably liable to happen in deep buckets where the angles *c* (see Figs. 10 and 11) are very acute. If elevators are too small for their load the buckets will be too full, and will commence to spill as soon as they begin to turn over the upper terminal. Flanged pulleys used to be employed for elevators, but they have been generally superseded by ordinary pulleys well rounded on the face. It is most essential that doors should be provided for the purpose of examining both the elevator top and well. At the former point it will be possible to determine if the delivery is a perfect one, and at the latter to free the elevator well in the event of a choke. There should also be doors in the elevator legs, preferably on each floor through which the elevator passes. At some point in the

elevator legs there should be a large door in front as well as at the back of the trunk, preferably near the elevator well. These doors should not be less than 3 feet in length, and are for the purpose of shortening the elevator band, should this become necessary.

For the purpose of tightening the band, the ends of the webbing are bound with leather strips about 3 inches wide, and to these two ends straps and buckles are riveted, so that the elevator can at any time be tightened by bringing this point to the place where the doors for tightening purposes are situated. Elevator bands for flour mills and granaries are best made of good stout cotton webbing. Leather is not advisable, as it never

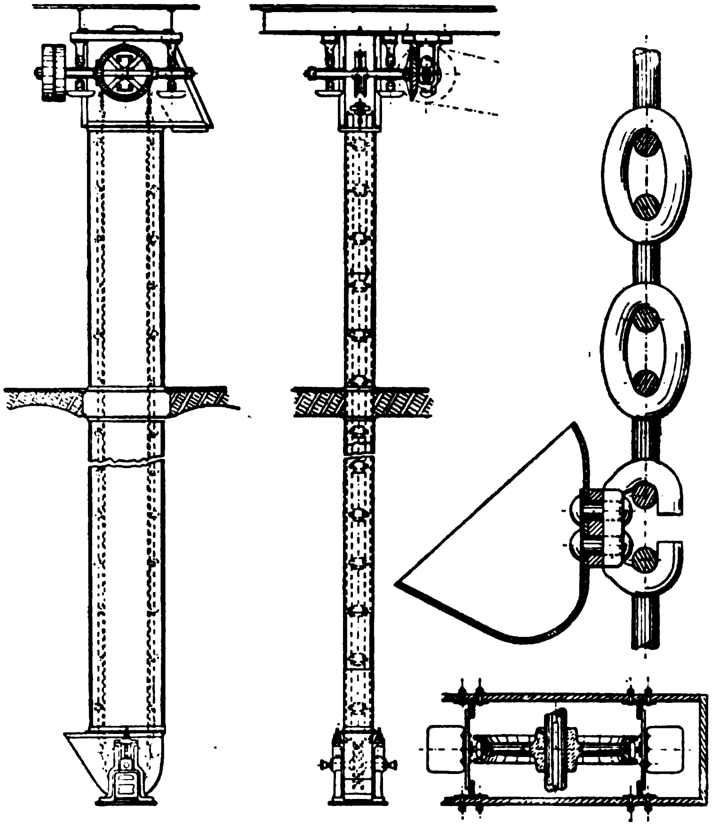


Fig. 12. General Arrangements of Cable-chain Elevator, showing Driving and Tightening Gear.

runs so true as a woven band. The elevator top, if of wood, should always be made in two halves, so that the spindle and pulley can be readily removed for repair if necessary, without dismantling the elevator. The top and bottom spindles must be perfectly level, or the belt will run continually to one side—a fault that is often not discovered until the sides of the webbing begin to fray out. In erecting flour-mill elevators the holes in the floor should be sufficiently large for the elevator trunk to fit easily, and the trunk should not be fixed to the floor but held in its correct position by wooden fillets, so that should the floor spring under an accumulation of sacks the weight will not be on the elevator leg, nor will the latter be affected by the vibration of the floor.

Iron elevator trunks, such as are often used in fireproof buildings, are very neat in appearance. They are made of four pieces of sheet iron, the edges of which are slightly bent, while a small pipe open on one side is pushed over the ends in order to fasten them together. If the trunks are made of wood, the point where two boards join should be fitted with iron tongues in order to prevent leakage of dust.

The best and safest plan is to drive each elevator by a separate pulley. Not more than two should be driven together by the same belt. Frequently a number of elevators are placed in a line, and one shaft runs through all the pulleys, and will drive the whole of the elevators. There are several reasons against this practice. In the first instance, it would be necessary that all the elevators should deliver in the same direction, which may be inconvenient. The difficulty can, however, be overcome by driving the elevator which should deliver on the opposite side by gearing from the shaft passing through the rest of the elevators, making those which ought to deliver in the opposite direction somewhat shorter or longer, in order to make them terminate either under or over this elevator shaft. There are, however, other objections to driving a number of elevators in a line by one shaft. If one elevator should choke, the accident is not so likely to be discovered as in the case of a number of elevators driven singly, for whereas in the latter case the driving belt would come off as soon as the choke took place, in the former case the main belt driving the line of elevators would necessarily, being much stronger, remain in its place, with this result, that the elevator pulley would continue to revolve against the elevator band, which would be held stationary through the accumulation of material. This has frequently been the cause of fires in flour mills, as the friction between the pulley and the band would be sufficient to cause the latter to ignite. The only advantage of having the elevators in one line and driven by one shaft is the saving of expense, and on that account this practice is too often followed, but to drive elevators singly or in pairs is far preferable.

Fig. 13. Driving Gear for Worm Elevator.

Cable-chain Elevators.—Elevators for handling rough and uneven material are sometimes driven by ordinary grooved pulleys and cable chains. Details of such an elevator are shown in Fig. 12.

The illustration shows the general arrangements of the elevator, with driving gear at the top and tightening gear at the bottom. The chain, and one bucket with its skidder bar, are shown to a larger scale, while a cross section shows the angle iron against which the skidder bars of the buckets run.

Worm Elevators.—Worm conveyors are also used as elevators, in which case the worm fits fairly tightly into a cylindrical receptacle. Such elevators must be driven 25 to 50 per cent. faster when used for elevating than when used for conveying.

There is no special feature about this particular type of elevator beyond what will be found under the head of worm conveyors, with the exception that the worm must be

of the continuous type, and that the pitch must not be more than half the diameter of the worm. Such elevators can be driven from top or bottom by bevel gear, the latter being the more general arrangement. Such a driving gear is shown in Fig. 13. The upright worm is erected within a receiving hopper, and the grain is admitted from the hopper to the worm by two or more inlets.

One appliance of this class varies slightly in the shape of the plates. It is said to be used for taking grain out of barges. It can no doubt be made to work all right, but the capacity would be so small that it would be of but little practical use. It is shown in Fig. 14, but seems rather a curiosity than an appliance for actual working purposes.

Gear Drives for Elevators.—For very large elevators, especially in cases where the available space does not admit of the internal elevator pulleys (sprocket or polygon wheels) being of large diameter, spur or bevel wheels having a ratio of 1:2 to 2:3 should be employed, together with a suitable countershaft.

Power required for Elevators.—This depends of course on the height of the elevator and on the weight to be lifted, but for practical purposes not less than twice the theoretical HP. should be allowed.

Fig. 15 shows a type of construction which is much in favour on the Continent, the one in question being the design of J. Pohlig of Cologne. The elevator well in this case being a masonry structure, does not offer all the advantages of an encased elevator.

This illustration is more intended to show the construction of the elevator itself, which consists of a pair of **I** girders stiffened by stays and by rods. The two terminals are fitted to the girders in the usual way, the lower one in this case being the tightening one. The elevator chain and buckets, instead of being fitted with slats running upon guides, are here supported and held in a straight line by a series of guide pulleys, the bearings of which are bolted to the girders on either side. The elevator here illustrated is used for loading a suspended railway by means of a hopper and shoot.

Fig. 14. Upright Worm Elevator.

Spouts and Shoots.—The spouts and shoots which receive the feed from elevators in immediate proximity to the latter should always be made of stout wrought iron, or better still cast iron. For smaller grain elevators, wood, with a sheet-iron lining, will be found sufficient. It is surprising how quickly even cast-iron shoots are worn through by the constant impact of the grain, not to mention heavier and harder substances. A sheet of indiarubber about $\frac{1}{2}$ inch thick secured to the point of impact will last longer than a cast iron plate of the same thickness. The shoots themselves should be

at an incline of say 5 to 10 per cent. greater than the angle of repose of the materials handled.*

Automatic Feeding Devices for Elevators.—If a system of conveying or unloading is employed which is more or less intermittent, and if the material so unloaded

Fig. 15. Mineral Elevator with Masonry Well Feeding Elevated Railway.

or conveyed is further to be handled by ordinary elevators or conveyors so that the further progress is to be continuous, the feed must be changed from an intermittent to a continuous one. The importance of an even feed in such cases is obvious, as too rapid a

* For inclines of shoots for delivery of coal see page 76.

heaping up of material may lead to chokes, besides causing an unfair strain which might lead to breakages and an undue consumption of power. If the material be delivered from railway or contractors' trucks, ropeway skips, or grabs, the load should be deposited in a hopper (with an adjustable outlet) sufficiently large to hold one charge of the material to be conveyed. The feed of the succeeding elevator or conveyor can be equalised in such a way that the hopper pays out its contents at the rate at which the elevator or conveyor can take it, while the truck or grab brings the next load.

In some cases and with some materials it is necessary to provide the exit of the hopper with a mechanical feeding device in order to get uniform delivery. This is the case where the material is not of uniform size, such as grain, seeds, or small coal, but where large pieces of coal and ore are mixed with the small. Such devices are sometimes on the principle of a revolving feed roller. One effective device is an inclined table which slides backwards and forwards under the opening of the hopper and allows a certain quantity to leave the hopper at each stroke, which quantity can be adjusted by opening or closing a vertical slide in the side of the hopper. A fairly uniform delivery can also be obtained by having a short spout from the hopper to the conveyor, the incline of which

Fig. 16. Mechanical Feeding Device for Elevators.

can be varied to give a slower or faster feed. A good plan is to fit under the hopper a breaker which reduces the size of the coal or minerals so that they can be more easily handled by the succeeding elevators and conveyors; but even in such cases the feeding devices here mentioned should be used, as the work of a breaker will always improve in proportion to the uniformity of its feed.

Fig. 16 shows a mechanical feeding device for elevators in which a short swinging conveyor is used, into which the coal falls through a receiving bin above. In this case the bin is fed intermittently by self-emptying narrow-gauge railway trucks. By the use of a slide the quantity of material it is desired to convey can be regulated. This feeding device can of course be used equally well for feeding other kinds of conveying appliances. It is always well, where possible, to drive the feeding device from the machine which is to be fed, so that when the elevator or conveyor is at a standstill the feed may also automatically cease. This is of great importance, for if arranged otherwise the conveying machine at its feed end would on starting be so full of material, that in attempting to start it the driving band would most likely come off, or if driven by a chain, breakdowns might be feared.

The installation shown in Fig. 16 represents the feeding device driven from the lower terminal. This is all right as long as the elevator is a chain elevator, so that its terminal must revolve with the elevator; but such an arrangement would not be suitable with elevators in which the buckets are fixed to a band instead of to a chain.

Another device, which is illustrated in Fig. 17, consists of a small trough suspended under the delivery end of a bin by four wrought-iron hangers. This shoot is put into oscillating motion by levers attached to one or two of the suspended arms. As the trough swings backward the coal it may contain will not slide backward with the shoot but will fall forward through a spout on to the conveyor or elevator to be fed. At the forward movement of the shoot the coal from the bin above will slide down into the space that is now left vacant by the pieces that have moved forward, so that the material is gradually and evenly deposited with each backward and forward motion. This shoot is put in motion by a crank and connecting rod in such a way that the throw can be altered at will, and the feed regulated to a nicety. Similar appliances are used in which the shoots are supported on four small rollers moving backward and forward on suitable rails. In such cases the shoot is generally level instead of being at an incline. The speed at which such feeding devices are run depends to a great extent on the size of the material. If small, the feeding device should take only a little at each movement and repeat the

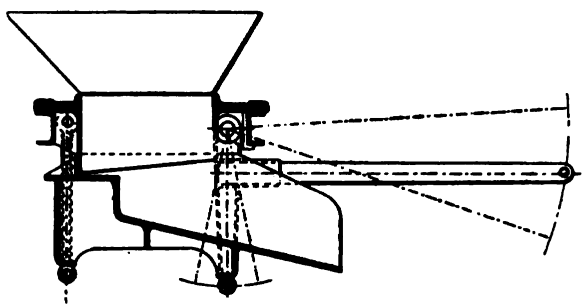


Fig. 17. Oscillating Feeding Device for Elevators.

movements rather more frequently; but if the material is large, the movements should be fewer, and a heavier feed should be allowed for each movement. For the former, a speed of 60 revolutions is not unusual, whilst for large coal the speed is reduced to as few as 30 revolutions per minute, or even less.

Elevators for Bulky Objects.—Elevators are frequently used for handling sacks, carcasses, casks, &c.; but of course the elevator buckets, or their equivalents, which have to deal with these large objects, must be shaped according to the loads they are intended to carry.

The elevator shown in the illustration, Fig. 18, is intended to handle sacks. Elevators for handling carcasses are similar, with this exception, that the appliances for the receiving and delivering of the loads are somewhat different.

Fig. 19 shows to a larger scale this portion of elevators for handling sacks, whilst Fig. 20 shows the same for barrels.

Much of the frozen meat handled in the foreign meat market is exceedingly hard when it arrives; but some of it, especially chilled beef, is in a very different condition, and the less it is handled the better.

The apparatus in question is therefore very serviceable, not only as a labour-saving

appliance, but also on account of its facility to handle the material with less injury than is usually the case with hand labour.

The hoist consists of two pairs of chains which run over two pairs of sprocket wheels, one pair being fixed on the top floor and the other on the bottom floor. Attached to the

Fig. 18. Hall's Elevator for Handling Sacks.

chains at certain intervals are cage-shaped buckets so arranged as to take the carcasses of the animals. One bucket will take a whole sheep or a quarter of beef.

The cages are suspended above their centre of gravity, so as always to be in a hanging position. They are loaded on any floor as may be convenient, and are delivered automatically on to any other floor as may be required.

On each floor there is a delivery platform, consisting of five or more steel arms, which may be set to deliver or to receive, or may be moved out of the way altogether by the system of levers which may be worked from any of the floors.

Thus at the floor on which the meat is loaded the steel platform is set to deliver the carcasses to the cages as they pass, the cages being formed also of steel bars which clear the steel arms of the platforms.

The carcasses are merely placed on these platforms, and find their way, one after another, into the cages as they arrive on the levels of the floors. They pass with the elevator chains over the top sprocket wheels, and as soon as they arrive on one of the delivery platforms the carcasses rest on the latter, whilst the cages pass through empty. The platform is inclined at an angle sufficient to allow the load to slide down on to the floor of the warehouse. Here the meat is taken up by the man who is attending to the storage, and passed by him into the proper bin.

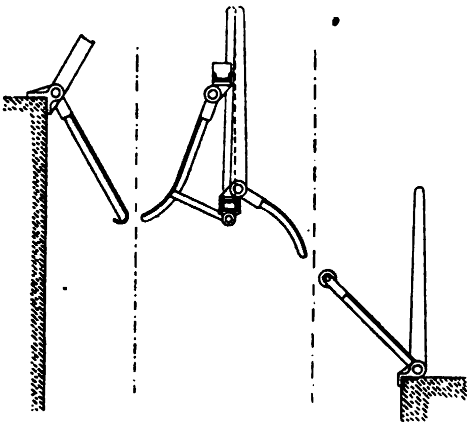


Fig. 19. Elevator for Handling Sacks.

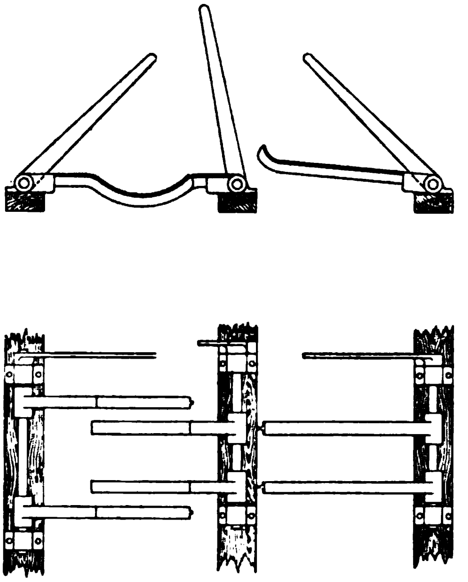


Fig. 20. Elevator for Handling Barrels.

Fig. 21 represents the apparatus designed for handling carcasses in connection with refrigerating stores in a London meat market.

All the platforms of the floors which are not required for loading and delivering are thrown out of the way by the system of levers already mentioned, which controls the whole system. They can also be pushed out of the way by the loaded cage as it passes.

Loading, it will be understood, takes place on one side of the elevator, whilst delivery is effected on the other side. Thus if the cage is set to load, say, on the bottom floor of the loading side, the elevator delivers on the other side on the top floor.

All the steel platforms on the loading side may be left undisturbed, as they will be pushed out of the way by the first loaded cage which passes. All those on the delivery side are moved into a vertical position, except those on the top floor, where the carcasses are arrested by a projecting steel platform as previously described, and deposited on the floor.

The appliances above described have been erected by J. S. Hall, Newark-on-Trent.

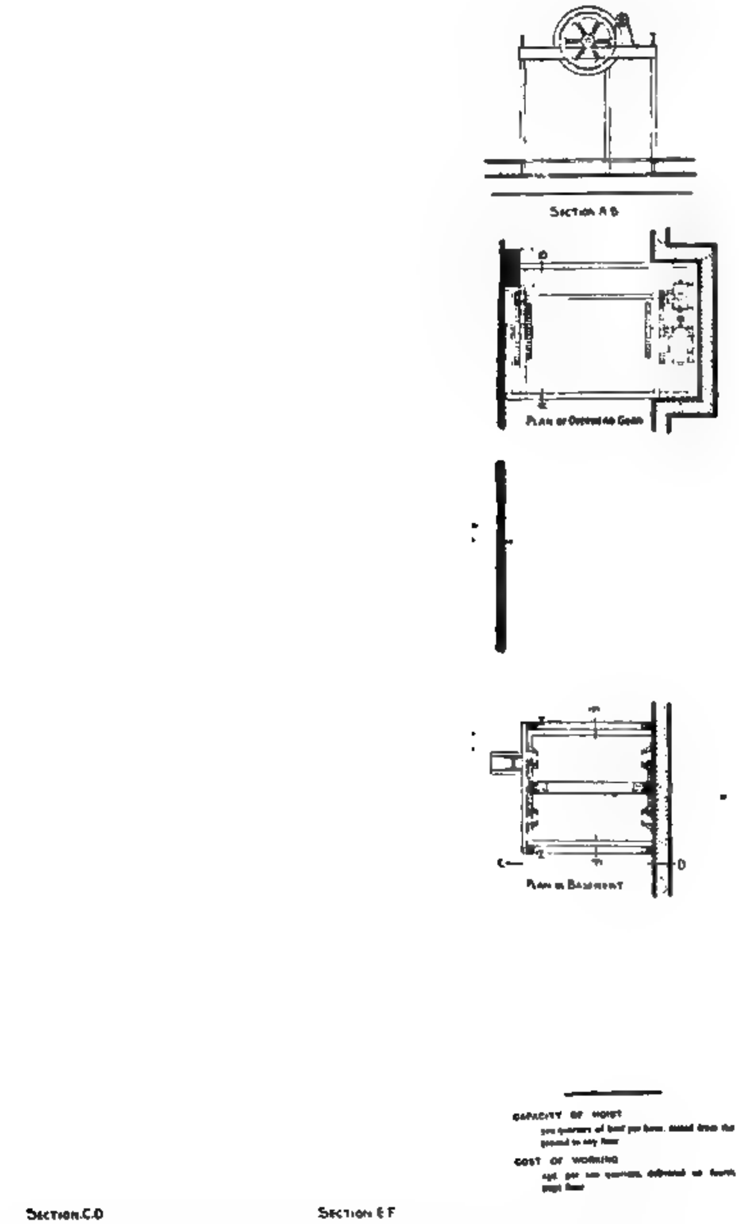


Fig. 21. Hall's Apparatus for Handling Carcasses in Refrigerating Stores.

Single-bucket Elevators.*—These appliances are generally called lifts or hoists, but they are practically elevators with one or two buckets. They are intended to raise in a vertical or sharply upward inclined direction loads of such material as is too uneven

* Single-bucket elevators for grain are in use at the granary of the Liverpool Docks.

in size to be handled by ordinary elevators, or for use in cases where the feed must be received and delivered intermittently. The single bucket or car of such elevators is generally provided with wheels which run on suitable rails.

Ordinary elevators have these advantages, that they transport coal or any other material without break of continuity, and that their capacity is practically unlimited, for if only a few inches are added to the width or depth of each elevator bucket the capacity is greatly increased, whereas single-bucket elevators have these disadvantages, if disadvantages they be, that they are intermittent and of comparatively small capacity, and that their installation and upkeep are apt to be more costly. It follows that the cost of handling material with one of these elevators will be greater than with most types of ordinary elevators.

These single-bucket elevators not being automatic, require some hand labour, however little it may be, for the purpose of filling the bucket at the lower terminal, the discharge at the other terminal generally being automatic. A single-bucket elevator will do excellent service where it is necessary to raise loads to a considerable height.

The cost of installation increases in proportion to the height to which the load is raised. This is a point in which the single-bucket elevator has an advantage over the continuous elevator, as in the latter case the increase in price is practically in ratio with the height of the lift. These elevators are likely to perform the best service in quarries, mines, and similar works, where heavy loads have to be raised to a considerable height, as is the case in deep shafts or for the service of blast furnaces. For this latter purpose elevators are very commonly used, and generally go under the name of furnace lifts or hoists. They have not yet, however, been introduced to the extent that one would wish to see, as even in large works the old-fashioned vertical hoist or lift is still largely in use. There are certain accessories to modern furnace hoists the use of which are calculated to greatly increase their efficiency. For instance, the opening of a slide is all that is necessary for the purpose of filling the buckets when they are ready for a charge, and it is in these accessories (on which the automatic action of the elevator more or less depends) that a great many iron-works are still very far behind. It is not an unusual sight to see the iron ore heaped up with a shovel and filled into small-gauge railway trucks which are pushed by hand to the lift, an operation which requires a large staff of men for loading and moving the waggons to and from the platform of the lift. Even if a modern elevator has been introduced, the full benefit will not be felt until the conveying appliances to it are automatic and mechanical.

Therefore in erecting installations of this kind, more or less automatic, it is most important that the whole plant should be worked in such a way as to be one mechanical installation divided into two sections, namely—

The section for conveying the material to the hoist, and the hoist itself.

It was in the United States that mechanical appliances for this purpose were first introduced, and many of the larger and up-to-date furnaces are now fitted with a device of this class. It is most essential that such elevators should be built in a very substantial manner, as breakdowns would stop the working of the furnace, with possibly disastrous results. The elevators are mostly so arranged as to obviate manual labour at the point of delivery at the top of the furnace, and the material, be it iron ore, limestone, or coke, is taken up a skip-load at a time and emptied automatically into the furnace. It is also essential that the feeding device which admits the material into the furnace should be so arranged as to distribute the material evenly, and at the same time to do so without allowing the gas to escape.

The general construction of these elevators consists of an inclined iron-trussed

bridge upon which the rails for the ascent and descent of the trucks are laid, whilst the hoisting gear for the manipulation of the trucks is laid on the ground level. The rails, when they reach the upper terminus, are generally bent into a more or less horizontal position, so as to tilt the truck for unloading purposes. In addition to this, the back wheels are supported either by rails that are bent at the terminus or else they have a different diameter on either side of their flanges, so that during the ascent the truck runs on its normal wheels, whilst at the terminus the larger diameter wheel engages with short lengths of extra rails and thus assists the automatic clearance.

To balance the dead weight of the bucket or car a counterweight may be used, or a double track may be employed, so that the empty car will descend on the one track whilst the loaded car is being drawn up on the other. In such a case the distributing hopper on top of the framework must have an elongated form, so as to take the charges alternately from buckets on either track.

Another plan which has been recommended is to lay the two tracks above each other, and to run one car on the upper and the other on the lower rails. The two cars will pass each other at about the centre of the framing, where there will be plenty of room for them to clear each other. At the terminals, that is to say, at the loading and discharging points, both will be in a suitable position for filling and discharging.

The difference in the capacity of the cars of course depends a great deal on the system on which the furnaces are worked and on their capacity. In the Brown Hoisting Machinery Co.'s apparatus the capacity of the carriers is generally 2 tons of ore or 1 ton of coke.

The time occupied in raising the load to a furnace 80 feet high would be 20 seconds, discharging it takes 4 seconds, and returning it 10 seconds, or 34 seconds altogether for each turn.

The speed at which the bucket travels is 5 feet per second, which, if no counterweights are used, would require a motor of about 100 HP.

Another estimate is for a motor of about 150 HP. for a truck of about 150 cubic feet. With a car of a capacity of 240 cubic feet, intended to serve a furnace of 550 tons daily capacity, the service would require 90 charges (which would each take two truckfuls of ore and lime and as many of coke) in twenty-four hours; therefore the car would have to make 360 ascents, and only four minutes could be given to each turn, including the filling of each truck.

Fig. 22 represents a typical installation for a furnace elevator as designed by The Brown Hoisting Machinery Co.

The stock of iron ore, coke, &c., required for use during one day is kept in large silos or bins, constructed of iron and wood, at the foot of the elevator. The main stock pile is kept on the open ground in the store-yard, and at the same time it serves the silos with the material to be used immediately. The material which has been brought by rail or from a distant part of the works is conveyed along an elevated railway and down an incline into the store hoppers. The trucks which are used for this purpose are hoppered to both sides, and discharge their load through two longitudinal hinged doors on each side of the truck. One of these trucks can be seen in position on top of the silos in the illustration.

The details of a store-yard must of course in a great measure depend on the conditions under which the material is received.

The bucket of the elevator receives its charge from one of the three hopper-bottomed bins. A weighing machine is provided so that a record of each charge can be kept. As soon as the truck is full it is hoisted, and its contents emptied into the furnace. The

hoist is electrically driven, and the electro-motor is placed in a cabin shown in the illustration.

The emptying of the skip is effected in the following manner:—The ordinary rails on reaching the entrance to the furnace are bent in a level direction so that the front wheels as soon as they reach this position proceed horizontally, whilst the back wheels, or rather that portion outside the flange, engage with a second pair of rails which are laid close to the ordinary track, and proceed in the same direction as the latter. The truck then rises until the floor of the skip has reached an angle of 45 degrees, when it automatically discharges its contents, as shown in the illustration, where one of the buckets is depicted in the position of unloading.

Fig. 22. Typical Furnace Elevator.

Fig. 23 shows a portion of a similar installation in which the skip is approaching the furnace top. One of the rear wheels with flange in centre is clearly visible. In this case the rear wheels engage with two short lengths of rails which are slightly further apart than the main track, so that the rear wheels proceed in a straight line. The main rails have been bent over a short distance in a horizontal direction, which gives the bucket the unloading position shown in the illustration.

The hoist cable runs over guide pulleys placed at the top of the furnace, and the cable is manipulated by an electrically driven winch in the cabin below. The descent of the truck is utilised to evenly distribute the feed from the hopper to the furnace, by causing the former to revolve. To this end the apparatus is provided with a very ingenious mechanism which only comes into operation as the car descends. After every charge deposited into the hopper the latter is turned round a few degrees, so as to give

the delivery of the next load in a different direction, and thus in turn the loads are distributed in all directions in the furnace.

This faculty of evenly distributing and thus mixing the material without the use of manual labour is usually deemed one of the great advantages of such furnace elevators, because the even distribution of material over the whole surface of the furnace is a point of great importance.

Fig. 24 illustrates the blast furnace elevator of the Iron and Steel Works, Hoesch, Dortmund. This installation was erected by J. Pohlig, of Cologne, and has been successfully at work since 1901.

Fig. 23. Portion of Furnace Hoist of the Brown Hoisting Machinery Co., showing Skip in a Discharging Position.

The lift or elevator stands at an incline of 53 degrees to the horizontal. The skip has a capacity of about 4 cubic yards, and is operated in a similar manner to that already described. The trucks used in this installation hold about $1\frac{1}{2}$ tons of coke or about $3\frac{1}{2}$ tons of iron ore.

The speed of travel is at the rate of 150 feet per minute when ascending, and at the rate of 250 feet per minute when descending, so that sixteen to twenty journeys are hourly accomplished.

The illustration shows the driving gear in a raised position. This consists of an 85 HP. electro-motor, which is coupled to a winding gear. There is, however, a

second motor standing by which can also be coupled to the winding gear in case of a breakdown.

Behind the motor-house is a receptacle for the coke, which is either conveyed to it by means of narrow-gauge trucks, or is brought by tipping trucks on the low level.

One example of the American elevator applied to British furnaces is that illustrated in Fig. 25, which represents the Brown hoisting and automatic distributing gear applied to the new furnace of Palmer's Shipbuilding Co. at Jarrow.

So completely automatic is this arrangement that one man can completely control the hoist. The inclined structure is built entirely of steel. All the bearings of the rotating parts are of the dust-proof pattern, fitted with large and easily accessible oil

Fig. 25. Furnace of the Palmer Shipbuilding Co., Jarrow on-Tyne.

cells. The mineral distributor is substantially built of cast iron, and is actuated by a pinion keyed on a shaft which by a suitable gearing and clutch is connected with the main hoisting machine, and this in such a way that when the bucket is ascending the clutch is out of gear. When, however, the bucket is descending, the clutch is thrown in gear, and turns the distributor several degrees.

The proportions of the bucket are such that four full loads constitute a charge. The furnace bell-charging cone is built of steel plates made up in sections bolted together, so that any section can be quickly dismounted and pulled away. To facilitate this operation, the cone sections are provided with rollers. The cone is also provided with explosion doors, and on referring to the figure it will be noticed that the equip-

ment includes an overhead travelling crane which permits the charging bell to be changed in a few hours.

The capacity of the bucket is 120 cubic feet, and the hoist equipment is capable of handling 1,300 tons of material per day. The bucket is built of steel plates, elliptical in shape, and is fitted with a false steel plate lining on the inside, so arranged as to be easily renewable.

The hoisting engine is of the non-reversible type, with double cylinder, 12 inches in

Fig. 26. Lrümann Furnace Hoist.

diameter, with 15-inch stroke, and is equipped with hand friction brake and a powerful friction clutch.

In order that the hoist operator may at any time be able to ascertain the exact height of the burden of the furnace for the purpose of preventing under or over charging, four rods are let into the top of the furnace through suitable openings, and the rods are connected with dials situated in the hoist operating house, so that as the rods are lowered into the furnace they indicate the exact height of the stock.

Another indicator fixed up in the cabin consists of a graded dial connected to the bell by a light wire rope. Its gearing is such that a drop of 1 inch of the bell corresponds

to a 3-inch pointer deviation on the dial. There is also an automatic indicator for signalling the number of buckets for each charge, the latter being indicated by the hoisting

Fig. 27. A Typical American Furnace Hoist.

drum. The dials of all the indicators are prominently placed in the operating house, so as to be well within the view of the hoist attendant.

Another modification of the inclined furnace hoist has been designed by Lürmann, of Osnabrück. In his opinion, it is a defect in the older types of construction that, as the car is tipped, the coarser material is shot at one side of the hopper, while the

finer material will lie in a heap on the other side. Moreover, the throw has the effect of breaking the coke, and thereby wasting it. Reference has already been made to the remedies for this defect. But over and beyond this objection to the older type of inclined furnace elevator, Lürmann correctly maintains that with only one hoist for each furnace any breakdown will bring the work of the furnace to a standstill.

Fig. 26 shows one of a couple of furnaces which have been connected by a gantry or bridge, against the centre of which, and between the furnaces, two inclined elevators are fixed.

The hoist car, which will take 6 to 20 tons of ore, as it is charged from the pockets,

Fig. 28. Portion of the Furnaces of the Carnegie Steel and Iron Co.

is bodily drawn up on the cradle of the elevator, and as it reaches the top, the rails on the gantry correspond with the rail portion of the cradle, and the car is carried by its own weight down a slight incline to the furnace, emptying itself as it passes over the conically shaped mouth. A travelling crane commanding the track of the connecting bridge and the furnaces is recommended as facilitating repairs.

As the loaded car automatically runs towards one of the furnaces, it raises a counterweight, which, as soon as the car is discharged, draws it back to the lifts.

The Lürmann principle has undoubtedly this advantage, that in case of a breakdown of one of the two elevators, the other could be used to serve both furnaces. A

second advantage no doubt is this, that the rails of the cradle, when in its lowest position, correspond with the rails which lie parallel to the furnaces and run right under the store bins from which the car is to be filled.

Fig. 27 shows an American furnace elevator erected by the Brown Hoisting and Conveying Machinery Co.

This hoist consists of an inclined iron-trussed bridge reaching from the floor of the stock-house to the top of the furnace shell, and from thence over the top opening of the furnace. On this inclined bridge are laid the rails, on which travels a skip or car containing a charge of from 1 to 3 tons as may be desired.

The track is so arranged at the top that the car automatically discharges itself as already described. The hoisting is effected by a two-cylinder engine, with a friction clutch drum, installed at the foot of the incline, while the skip is lowered to the bottom for refilling by means of a powerful foot brake, without reversing the engine. The top hopper is covered by a conically built structure with an opening about 4 feet square, and is also equipped with explosion doors. It rests on the top ring of the furnace and covers the bell and hopper. The lowering and raising of the bell is accomplished by a simple device under the control of the operator.

Fig. 28 shows a portion of the Carrie furnaces of the Carnegie Steel Co., with the conveying plant serving them. It was the work of the Brown Hoisting and Conveying Machinery Co. The coal-tip on the right deals with the material which is received by rail. The material discharged from the rail trucks into the bin is withdrawn into buckets holding about 10 tons each. These buckets are placed on the electric cars, each of which can hold four buckets. The buckets are then picked up by the Brown travelling crane, as shown in the illustration, and the ore is emptied into the stock piles or into the bins in front of the furnace. From the bins the ore is drawn out through suitable openings into electric travelling trolleys, one of which is shown in Fig. 511, page 483. These are so made as to hold one charge of the elevator skip which takes the material to the top of the furnaces. The trucks are equipped with weighing machines, so that the exact quantity required can be taken at each trip.

CHAPTER III.

WORM CONVEYORS.

There are many types of conveyors, and although some of them are of great antiquity, they are still employed, and do serviceable work for a limited number of purposes.

Under the heading of conveyors the different types are referred to in the order of their antiquity.

The oldest type of conveyor is undoubtedly the *Archimedean Screw or Worm Conveyor.*

This consists of a continuous or broken blade screw round a spindle, which screw is

Fig. 29. Earliest Construction of Worm Conveyor.

made to revolve in a suitable trough, and thus propels the material slowly from one end of the trough to the other.

The first specimens of worm conveyors were probably used in the earliest flour mills,

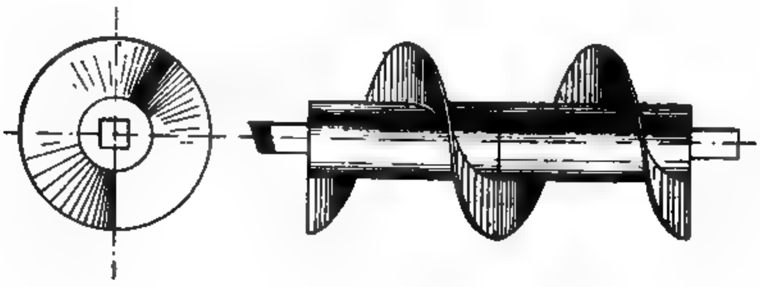


Fig. 30. Worm Conveyor composed of Cast-iron Plates and fitted with Square Spindle.

and were made of soft wooden octagonal spindles into which were driven hard wooden blades with pegs at one end.

Such a worm is illustrated in Fig. 29.

In course of time this construction was improved upon by cast-iron sections being

threaded on a square iron shaft, which was turned for suitable bearings at intervals of from 6 to 10 feet.

Fig. 30 shows such a conveyor.

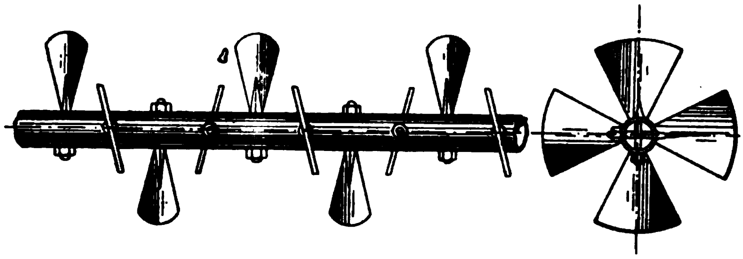


Fig. 31. Paddle-worm Conveyor.

More modern constructions sometimes used at the present day are illustrated in Figs. 31 and 32.

Fig. 31 represents a so-called paddle worm constructed of a series of blades forming

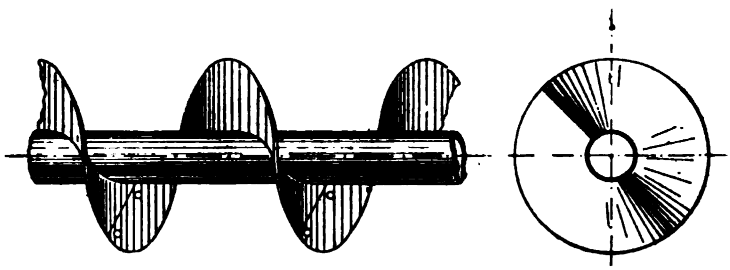


Fig. 32. Continuous Worm Conveyor.

together as nearly as possible a complete screw. Each of the blades is fixed to a central shaft or spindle by means of its shank, which is tapped and fitted with a nut. The spindle is made of steam pipe in lengths of about 8 feet, the different lengths being

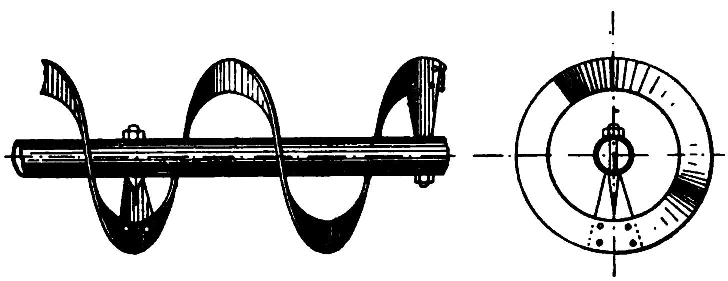


Fig. 33. Spiral or Anti-friction Worm Conveyor.

coupled together by turned gudgeons, which answer at the same time as journals for the bearings.

The continuous worm is illustrated in Fig. 32, the only difference between this and the last-mentioned conveyor consisting in this, that the screw is not composed of

single blades, but is one continuous sheet-iron spiral which is secured to the spindle at intervals more or less frequent according to the size and capacity of the worm. The most approved method of construction is to cut a narrow groove in spiral form on the spindle and to secure the sheet-iron spiral into this groove.

There is a fourth form of worm which ought to come under this heading, *i.e.*, the spiral or anti-friction conveyor. This was introduced about the year 1887, and is a very simple kind of conveyor.

Fig. 33 illustrates this appliance.

It has the advantage of being inexpensive. The spirals which form the principal part are made by special machines. The illustration shows the mode of fixing the spiral to the spindle.

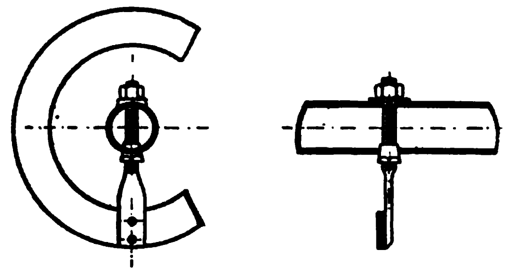


Fig. 34. Method of Fixing Spiral of Conveyor to Spindle.

Fig. 34 shows another method.

The spiral is made of various sections, from a round bar about ½ inch in diameter to L or T section. The best form, however, is the flat bar.

In all worms the ratio of the diameter to the pitch must depend upon the kind of material to be conveyed. It ranges from one-third to a pitch equal to the diameter of the worm, and even greater. The greater the pitch the greater the capacity and consequently driving power required. It is therefore usual to employ worm conveyors for heavy materials, such as cement, with a smaller pitch, and those for grain with a larger pitch.

The following table gives the capacity of worm conveyors of different diameters with their respective pitch, speed, and capacity for continuous, paddle, and spiral conveyors. It is obvious that the capacity of a continuous worm is greater than that of a paddle or spiral conveyor, these latter being about equal in capacity if other conditions are equal.

CAPACITY OF WORM CONVEYORS.

Diameter.	Pitch.	Diameter of Hollow Spindle.		Revolutions per Minute.	Capacity.	
		Inner.	Outer.		Continuous Worm Conveyor.	Paddle and Spiral Worm Conveyors.
Inches.	Inches.	Inches.	Inches.		Cubic Feet per Hour.	Cubic Feet per Hour.
4	2	1	1⅜	130	55	45
6	3	1½	1 15/16	120	150	125
8	4	1½	1 15/16	100	300	250
9	4½	1½	1 15/16	100	480	400
10	5	2	2 7/16	90	600	500
12	6	2	2 7/16	90	1,000	825
14	7	2	2 7/16	80	1,400	1,150
16	8	2	2 7/16	70	1,900	1,575
18	9	2	2 7/16	60	2,300	1,900

Experiments with "Paddle" and "Spiral" Worm Conveyors.—In order to ascertain the respective merits of spiral-worm and paddle-worm conveyors, the author made a series of experiments in March 1889 which point to the fact that when running at a slow speed the paddle worm is of greater efficiency, while with a high speed the advantage is on the side of the spiral worm. At a speed of 150 revolutions per minute the efficiency of both is about equal, while if run at higher speeds the spiral worm increases and the paddle worm decreases in capacity.

The following is a summary of the results of the experiments. The material experimented with was sawdust.

First Experiment.—The worms experimented with consisted of a paddle worm 4½ inches in diameter by 6 inches pitch, with a spindle of an external diameter of 1½ inches, and a spiral worm 4 inches in diameter by 3 inches pitch, on a 1-inch spindle. Paddle worm without intermediate bearing. Spiral worm with one intermediate bearing. Speed of both, 145 revolutions per minute.

	Paddle.	Spiral.
Actual capacity in bushels per minute - -	2·77	1·11
Theoretical capacity in bushels per minute -	5·545	2·297
Efficiency, per cent. - - - -	49·95	48·324

Second Experiment.—Both worms as above, but the speed of both 300 revolutions.

	Paddle.	Spiral.
Actual capacity in bushels per minute - -	3·55	1·97
Theoretical capacity in bushels per minute -	11·475	4·762
Efficiency, per cent. - - - -	30·9	41·3

Third Experiment.—Both worms reduced to half their length, so that neither had an intermediate bearing, and both running at 300 revolutions.

	Paddle.	Spiral.
Actual capacity in bushels per minute - -	4·44	2·61
Theoretical capacity in bushels per minute -	11·475	4·762
Efficiency, per cent. - - - -	38·69	54·81

Conveyors of double pitch have twice the capacity, and should be driven, if more than 9 inches in diameter, by means of gearing and countershaft, unless they are very short.

Worms are fitted into a wooden or iron trough so as to leave a clearance of between ⅛ and ¼ inch. The different lengths are supported at intervals of 8 feet for 4-inch worms, 8 to 10 feet for 6 to 10 inch worms, and 10 to 12 feet for 12 to 18 inch worms. A continuous worm is more rigid than a paddle worm, and may therefore be in longer lengths, *i.e.*, have fewer intermediate supports.

A detail of great importance in all worm conveyors is the intermediate bearing; this, if cumbersome, obstructs the passage of the material, a drawback which must be carefully avoided. As all adjustable bearings are in halves and of necessity bulky, it is preferable to choose whole or bush bearings, although they lack some advantages that the former possess. The best intermediate bearing is a small phosphor-bronze bush, secured by a short piece of pipe to a cast-iron support. The pipe is screwed into the support and secured by means of a lock nut. The bearing can be oiled through the pipe.

Figs. 35 and 36 show such a bearing, and also a simple form of an adjustable bearing in halves.

Fig. 37 illustrates another type of intermediate bearing. It is similar to that illustrated in Fig. 35, with the exception that the bearing is in halves and held in position

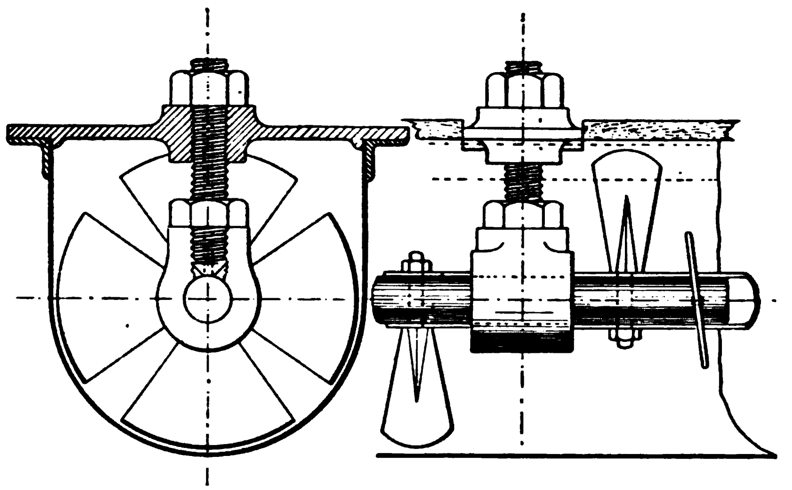


Fig. 35. Solid Phosphor-Bronze Worm Bearing.

by two supports in an oblique position, which give it greater rigidity. Such bearings are suitable for worms of large diameter.

The construction almost explains itself, the two halves of the bearing being con-

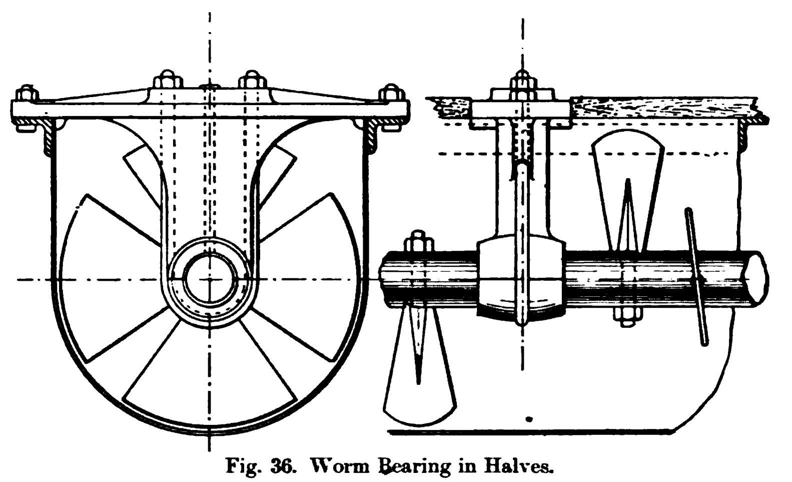


Fig. 36. Worm Bearing in Halves.

nected by a staple which is V-shaped, and by the two distance pieces which are threaded on the shanks of the staple.

The different lengths of worms are coupled together in various ways, chiefly by means of end gudgeons, a portion of which forms the journal for the intermediate bearings. Fig. 38 shows an end gudgeon coupling two worm sections. Three bolts, or else the shanks of the worm plates, form the fastening. The end of each worm

section is strengthened by a collar which secures the spindle against splitting. These rings or collars are not necessary when stout steam piping or hydraulic piping is used.

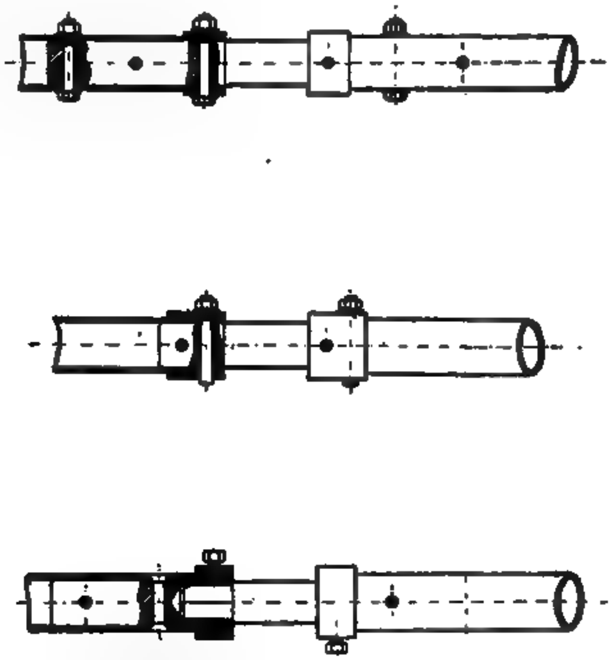
Fig. 39 shows another coupling with a short gudgeon, and two cotter bolts for each fastening. In this case the collar over the end of the pipe is indispensable.

Fig. 40 shows yet another mode of coupling worms together. The coupling consists of two short gudgeons, each with a square hole into which a short coupling piece fits. The advantage of this coupling is that it can be very quickly disconnected, as it is only necessary to slacken the set screws and push one half of the worm 3 or 4 inches to one side, when the coupling piece can be taken out.

Fig. 41 shows a coupling sometimes used in connection with continuous worm conveyors. The coupling consists of a worm section with a stout sleeve which is split longitudinally, and is secured tightly over the junction of the two halves of the worm.

Fig. 37. Worm Bearing in Halves.

Delivery of the material from a worm conveyor can be effected at any number of points. It is only necessary to provide a suitable outlet. Such an outlet should be as



Figs. 38, 39 and 40. Types of Worm Couplings.

long and as wide as the diameter of the worm, if it is desired to get the whole of the feed through it. This must be so, as the worm delivers only on its leading side, and is practically empty on the other side. The lid which covers the worm box or trough

should not be fixed, but should lie loose on top, because in the event of an accumulation of material occurring through the choking of a spout, unless the material in the worm can force the lid and throw the stuff out, the worm, if continuous, will be stripped, or the blades broken, if it be a paddle worm.

In this connection the tubular worm conveyor deserves to be mentioned, for, though not often used, under some conditions it is useful. It consists of an iron tube with a continuous spiral fitted to its inner periphery, as shown by Fig. 42. When at work it revolves bodily on suitable rollers. This form of conveyor is more expensive and needs

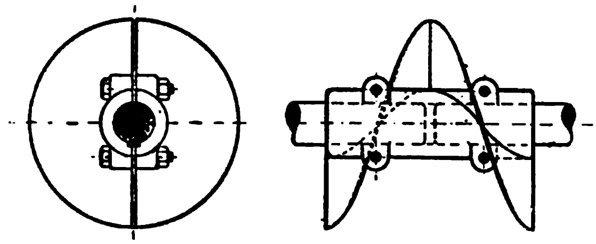


Fig. 41. Coupling for Continuous Worm Conveyor.

more driving power than an ordinary worm, and unless its speed is within the correct limits the capacity deteriorates, as the centrifugal force counteracts the propulsion; for it must be remembered that with this appliance the conveying is effected by gravity.

A series of experiments with this conveyor were made in 1868 by Mr Lyster, engineer of the Liverpool Docks. These were fully dealt with in a paper read by Mr Percy Westmacott before the Institution of Mechanical Engineers. The results of these

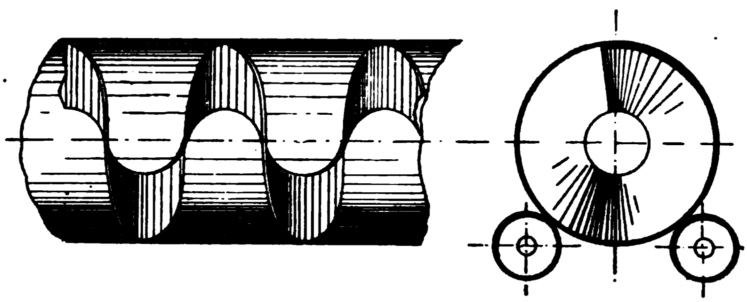


Fig. 42. Tubular Worm Conveyor.

experiments are here given. A tubular worm, 6 inches in diameter and of 2 inches pitch, with a depth of plate of 2½ inches—

At 60 revolutions per minute delivers at the rate of 28 cubic feet
„ 80 „ „ „ „ 36 „
„ 100 „ „ „ „ 30 „
„ 140 „ „ delivery ceased altogether, and the grain was carried round and round the tube.

A second trial was then made with a 30-inch worm, calculated on the results of the

preliminary experiment to discharge at the rate of 50 tons per hour. The length of this worm was 18 feet, and it had a pitch of 12 inches, or two-fifths of the diameter. The body of the screw was properly balanced and revolved upon finely adjusted rollers, carried in cast-iron frames. With this worm a speed of 36 revolutions per minute was found to be the most effective, and at this speed the grain was carried up the side of the screw, about 5 inches above the centre of the tubular casing, and the discharge was 63½ cubic feet, or about 80 tons of wheat per hour—a much better result than had been calculated upon. The power required was 0·40 HP. per foot run, and the sectional area of the body of grain was 36 per cent. of the whole area of the casing.

A third experiment was also made with a 12-inch worm, with a pitch of 12 inches, with a view to ascertain the effect of the quicker pitch. This worm was driven at the same speed of 36 revolutions per minute, the delivery being 10 tons of wheat per hour, with a sectional area of only 17 per cent. The pitch of two-fifths of the diameter proved most effective in these trials.

A case in which the tubular worm conveyor is very useful is where grain has to

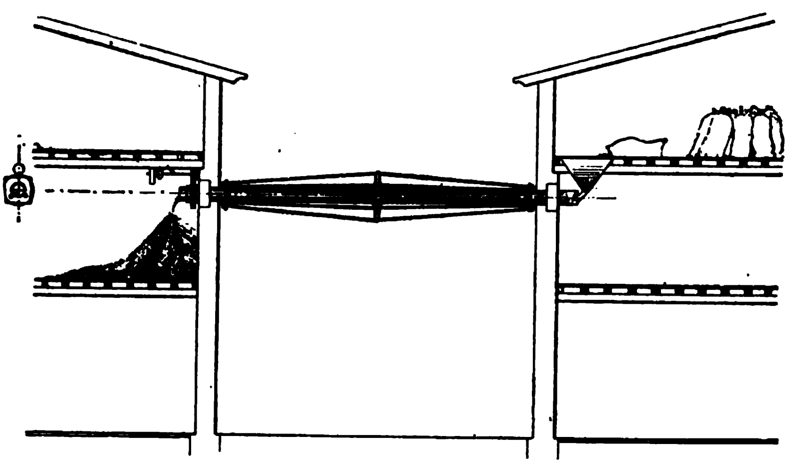


Fig. 43. Example of Tubular Conveyor.

be conveyed from one building to another on a level, but where no bridge is available to which any other kind of conveyor could be attached. The tube can be made as strong as necessary, and trussed by means of a spider in the middle and a number of tie-rods as shown in Fig. 43.

Power required to Drive Worm Conveyors.—For the sake of easy comparison with other conveyors this estimate is based on a load of 50 tons of grain per hour to be conveyed to a distance of 100 feet.

An 18 or 20 inch continuous worm will do the work if driven at 60 revolutions per minute, and the power required will be 18½ to 19 HP. To convey cement would absorb somewhat more power on account of the greater friction of the worm blades and the box against the cement.

The principal advantages of a worm conveyor consist in its great simplicity and small first cost. The terminals are much less expensive than those of most other types of conveyors. Short worm conveyors can therefore be procured at a much smaller cost

than short conveyors of other types. Worm conveyors are of great service where a mixing of the material to be conveyed is desired.

For example, when cement and sand in a dry state are to be conveyed, they will arrive at the delivery end well mixed. The disadvantages are the large amount of driving power required, the grinding action on the material to be conveyed, and the great wear and tear if the conveyor be used for hard and cutting substances.

CHAPTER IV.

PUSH-PLATE OR SCRAPER CONVEYORS.

THE next class of conveyors to be considered are those of the drag or push-plate type. A great deal of what has been said in reference to elevators also applies to push-plate conveyors. This conveyor varies much in minor details of construction, but in principle it consists of a fixed open trough of stout sheets of steel or iron, and often of cast iron. The material to be conveyed is deposited in this trough and is pushed or dragged along by a series of plates attached to an endless chain, which latter with its attachments revolves over terminal pulleys, so that only half the chain is at work at a time. The chain should be attached as nearly as possible to the centre of the push plates. The push plates are not generally allowed to touch the bottom of the trough, and are therefore fitted with skidder bars which slide on well-greased angle bars forming portions of

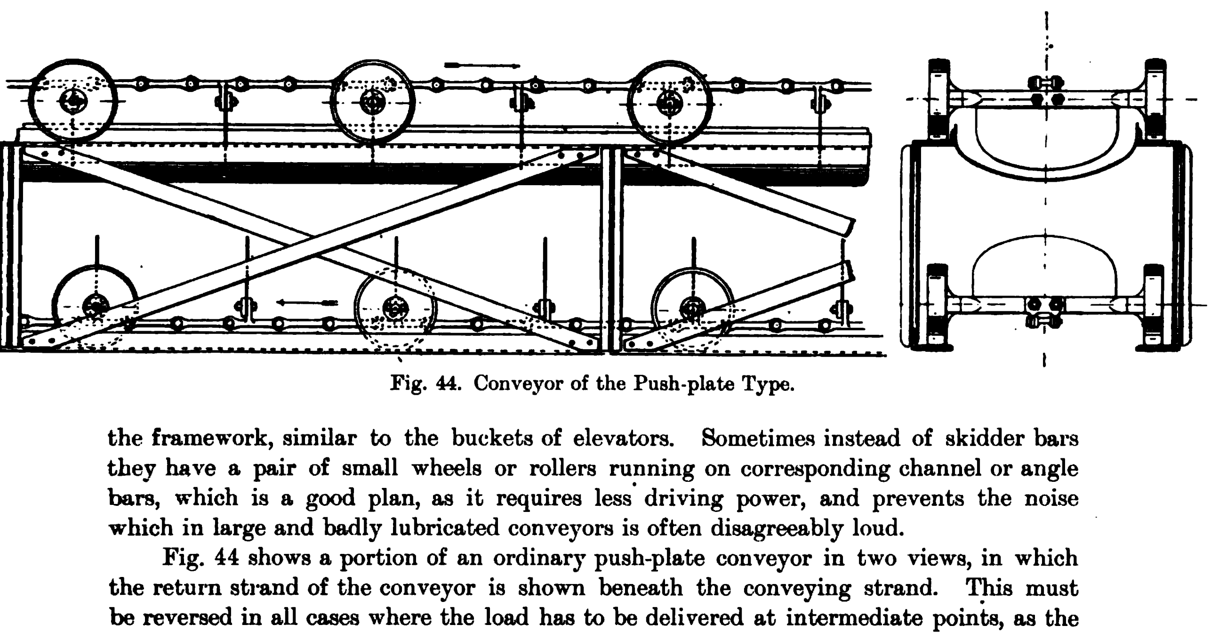


Fig. 44. Conveyor of the Push-plate Type.

the framework, similar to the buckets of elevators. Sometimes instead of skidder bars they have a pair of small wheels or rollers running on corresponding channel or angle bars, which is a good plan, as it requires less driving power, and prevents the noise which in large and badly lubricated conveyors is often disagreeably loud.

Fig. 44 shows a portion of an ordinary push-plate conveyor in two views, in which the return strand of the conveyor is shown beneath the conveying strand. This must be reversed in all cases where the load has to be delivered at intermediate points, as the spouts leading the material away would otherwise foul the return strand.

The trough is often made of two pieces of channel iron, with an iron plate riveted underneath. The skidder bars of the leading strand of this conveyor run on slats of hard wood which are fastened on the channel irons, whilst the chain of the return strand runs over guide rollers. Sometimes the wooden slats are dispensed with, and then the skidder bars are allowed to run on the trough itself (see Fig. 45).

The conveyor illustrated in Fig. 46 has a trough similar to that just described, but the pushing agent is different altogether. It consists as it were of a large chain composed of links of flat iron, between which and on the top of which the material is conveyed. The links are of a pitch equal to their width, and are 3 to 4 inches wide by ½ inch in thickness. The speed at which the chain travels is from 150 to 180 feet

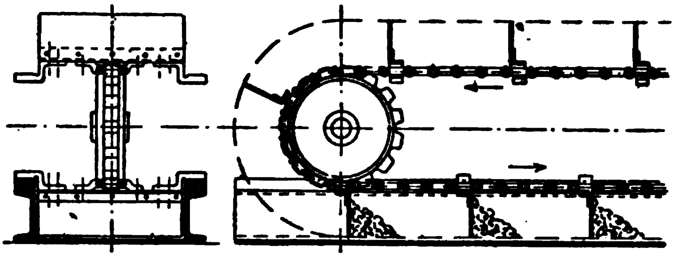


Fig. 45. Further Type of Push-plate Conveyor.

per minute. The terminals are hexagonal, whilst the intermediate supports for the return strand consist of ordinary rollers which are about 6 inches in diameter.

A further type of conveyor is illustrated in Figs. 47 and 48.

It was originally intended for the Manchester Gas-works, where it was erected for conveying hot coke. The work was executed by West's Gas Improvement Co. This conveyor consists of a cast-iron trough 24 inches wide by 9 inches deep. The chain is

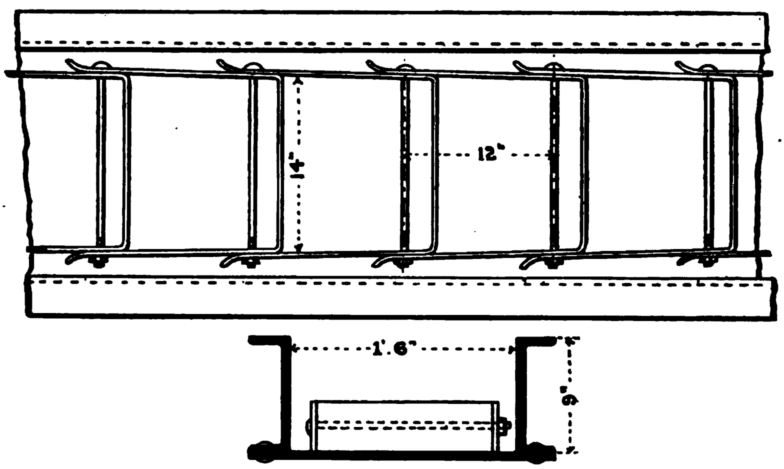


Fig. 46. Push-plate Conveyor.

composed of cast-steel links bolted together, while to each alternate pair of links cast plates are fitted which match the section of the trough but do not touch the sides or the bottom of it. Between the links which carry the push plates are placed sliding blocks which rest on a renewable central rail. The pins joining the links together pass loosely through the small rollers (Charles Hunt's patent) for the purpose of minimising friction and the wear in passing round the track, and whilst on the terminals. This construction is well designed, as the chain pulls its load on or near the centre of the push plates, and not, as in most cases, above.

Fig. 49 shows a form of push-plate or scraper conveyor known as the Monobar conveyor.

The illustration shows both the upper and lower strand of the conveyor. The length is 200 feet, and the capacity 40 tons per hour. The trough is made V-shaped, as well as the scraper plates.

Fig. 50 is another type of push-plate conveyor, the design of the Berlin Anhaltische Maschinenbau Aktien-Gesellschaft, its special feature being that in place of the push plates the conveying chain supports frames which resemble small bottomless boxes, the

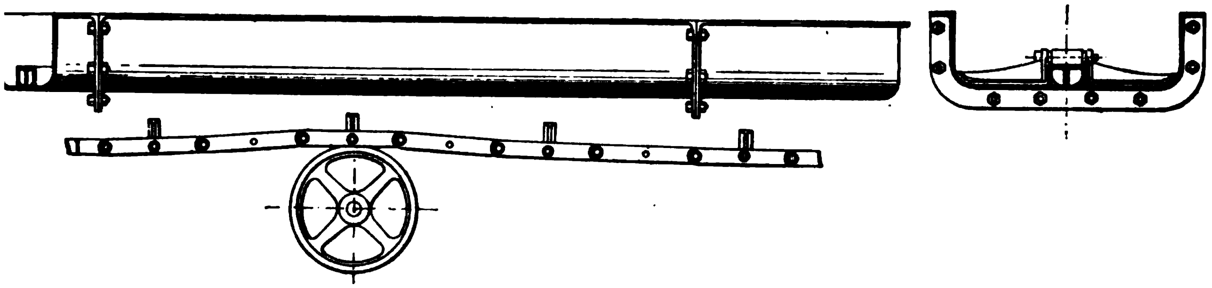


Fig. 47. Push-plate Conveyor with Cast-iron Trough.

base for these frames being supplied by the conveyor trough itself. At the sides of this conveyor trough, which is practically a smooth plate, are fixed channel irons in which the guide pulleys of the sections run. For the return half of the conveyor the angle iron takes the place of the channel, the chain of this conveyor being composed of long links which nevertheless run on a specially designed and constructed circular wheel instead of running over a polygon wheel, as is generally the case. Each link of the chain is fitted with two studs in addition to the two ordinary pins, which fit into suitable grooves in the two terminal wheels.

The advantage of this type of conveyor is that it can be run uphill at a considerably steeper angle than an ordinary push-plate conveyor. A further advantage is this, that

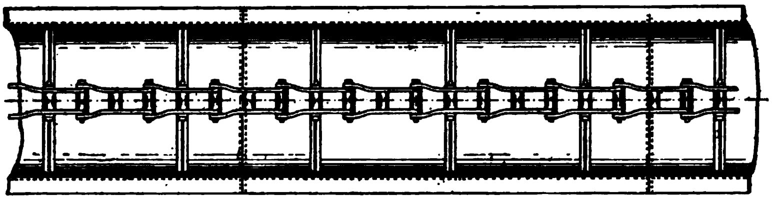


Fig. 48. Plan of Fig. 47.

there is no friction between the sides of the channel and the material being conveyed, the sides not being stationary, but travelling with the push plates, as described.

In America, scraper conveyors are also used for forming stock heaps of minerals and coal in yards, this operation being effected, as shown in Fig. 51, by shooting the material into conical heaps of heights up to 60 feet and diameters of 200 feet. The cone is surmounted by an apparatus shaped like an equilateral triangle, of which one side contains a scraper conveyor. To this the coal is brought by some mechanical means. The bottom of the trough consists of a thin iron band, the lower end of

which is wound round a drum, and can therefore be withdrawn or replaced. When building a stock pile, the band is slowly drawn towards the spot where the coal is being

Fig. 49. View of Monobar Conveyor.

delivered, so that the material is not subjected to a fall, but heaps up at its natural angle of repose.

The second conveyor serves to take the coal from the stock heap as shown in AB, Fig. 51. It is mounted on a beam which rotates at A, and can be operated by cables

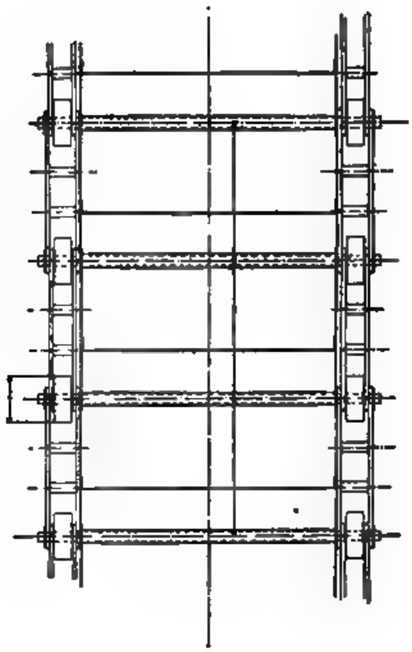


Fig. 50. Push-plate Conveyor with Travelling Sides.

Fig. 51. American Scraper Conveyor for Building Stock Heaps.

round its axis. It can thus be supported on a number of lines of rail converging on A. Both strands of the conveyor lie in the same plane close to the ground, and running in either direction, can simultaneously draw from two different heaps. They take the material from the outer border of the cone and carry it to a point A, where another conveyor is ready to receive and deliver the coal to tower C, from which it falls direct into railway trucks.

Ice Conveyors.—Elevators, or perhaps more correctly conveyors for ice-houses, are used, particularly on the Continent. They were perhaps more often used before the introduction of refrigerators, but are still in general use in the vicinity of the Baltic Sea. These appliances very much resemble push plates. The trough in which the ice slides up into the ice-house is made of wood, while the scraper plates are attached in the usual way to the chain and drag the ice up the incline.

Fig. 52 shows a cross section through such an ice-house. The pieces of ice are

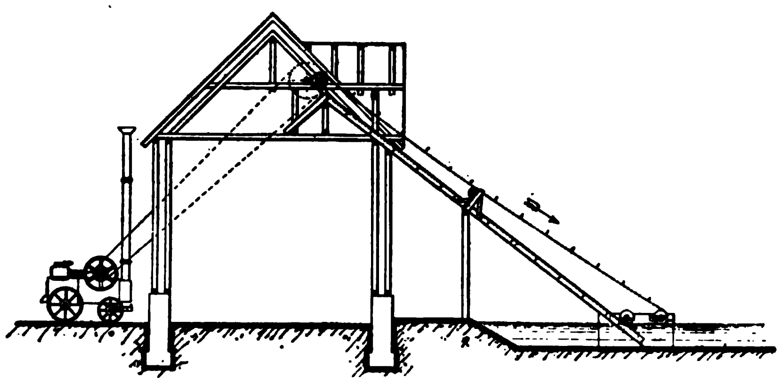


Fig. 52. Push-plate Conveyor for Ice.

pushed into the lower end of the trough, where they are brought into connection with the plates, and finally deposited in the store.

Capacity of Push-plate Conveyors.—This depends on the size of the trough, and the pitch and speed of the plates. The pitch of the plates ranges from 18 to 36 inches, and the speed of travel from 50 to 180 feet per minute. For coke and other friable substances the speed should not exceed 50 to 90 feet per minute, whilst in cases where the breakage of the material is of minor importance, the maximum speed, 180 feet per minute, may be employed.

For example, a conveyor with a trough 24 inches wide, having the plates 24 inches apart, and running at a speed of 100 feet per minute, would convey 30 tons of coal per hour. A push-plate conveyor for hot coke with a 27-inch trough, and with malleable iron plates 24 inches apart, running at about 48 feet per minute, would deliver about 20 tons of coke per hour.

Power required to Drive Push-plate Conveyors.—This must depend on the nature of the material to be conveyed and on the condition of the trough. For instance, cement clinker and coke would take more power to convey than coal; but as this type of conveyor is altogether unsuited for hard and cutting substances on account of the great

wear and tear, no examples are here given of a conveyor for such materials, the following figures being for coal conveying.

A push-plate conveyor, 100 feet long, conveying coal at the rate of 50 tons per hour, will require a driving power of 12 HP.

The Push-trough Conveyor.—There is a further type of conveyor, which, though different altogether from the push-plate conveyor, ought perhaps to be dealt with under the same heading. There are several of these conveyors, built on the same principle, but with slight variations of detail. One of the older type consists of an open iron trough in which are manipulated a number of spade-like push plates, which are hinged to an iron rod carried by means of guide wheels longitudinally over the top of this trough. The rod, with its plates, is set into an oscillating motion, making about 60 strokes per minute, and having a stroke of 30 to 32 inches. The plates are hinged and ride over the top of the material during their backward motion, whilst during the forward motion they bury themselves in the material to be conveyed, and push it forward. There appears to be no practical advantage in this conveyor over ordinary push-plate conveyors, beyond the fact that it occupies somewhat less headroom on account of having no return strand.

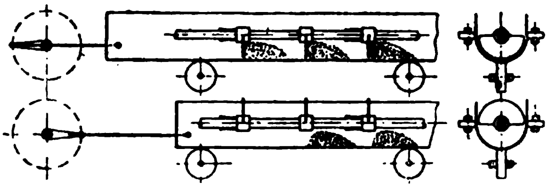


Fig. 53. Push-plate Conveyor on the Commichau Principle.

A conveyor of similar construction is built on the Commichau principle, in which case the trough oscillates as well as the plates. This conveyor is illustrated in Fig. 53, which shows it in its extreme forward and its extreme backward position. The upper drawing shows the trough on the point of starting the forward movement, pushing the material forward by means of plates attached to the longitudinal rod. The lower illustration gives the conveyor ready for its backward movement, the plates having been turned upward through a turning motion of 180 degrees of the spindle instead of being hinged as in the former case.

It is only in short conveyors that the trough receives a backward and forward motion. In the case of greater lengths the spindle with its plates performs the backward and forward as well as the turning motion, while the trough remains stationary. Conveyors of this type are said to have been built for considerable lengths, but they appear to be more generally used for short lengths. It is said that a trough 12 inches wide will convey 50 tons of coal per hour.

It is claimed for this appliance that it is more suitable than worm conveyors for handling material of a sticky nature.

CHAPTER V.

TROUGH CABLE CONVEYORS.

THIS type of conveyor is undoubtedly on the push-plate principle, and might therefore have been included under that heading. It consists of a V or U shaped wooden trough,

Fig. 54. Type of Cable Trough Conveyor with V-shaped Trough.

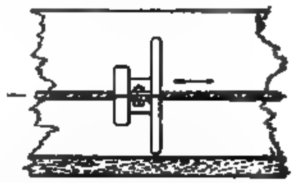


Fig. 55. Type of Cable Trough Conveyor with U-shaped Trough.

through which runs a wire rope with disc-like attachments. The trough may be lined with sheet iron according to the nature of the material to be conveyed. This kind of

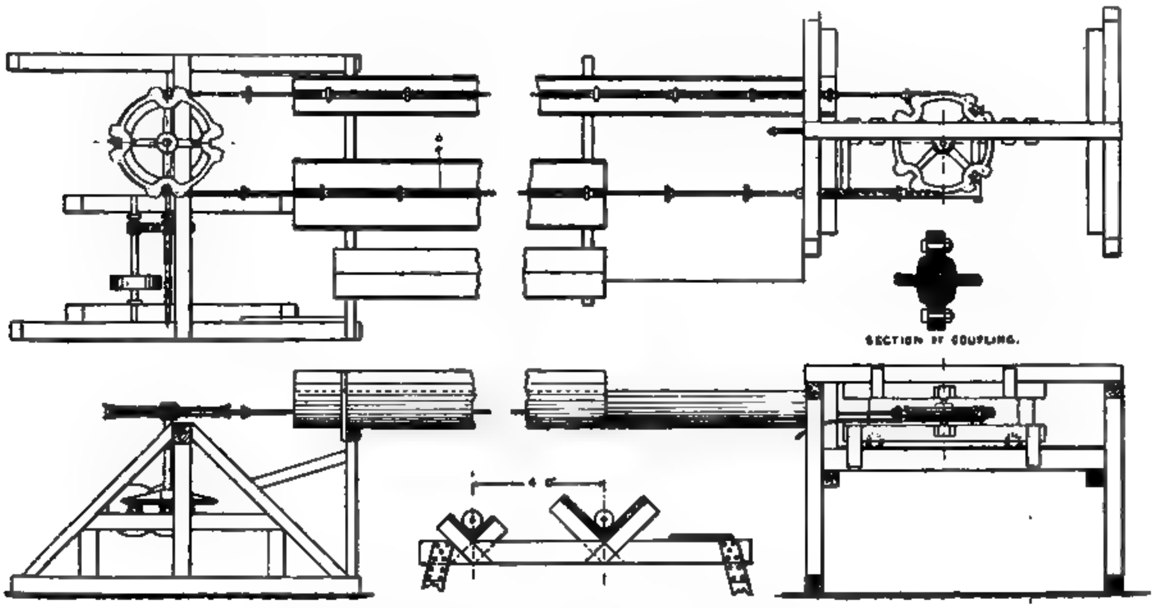


Fig. 56. Complete Installation of Cable Trough Conveyor.

conveyor is suitable for conveying light and bulky material, preferably in a straight line and down an incline. It is well adapted for handling timber, blocks, chips and shavings, peat, pulp, hay, &c., but has occasionally been used for heavier materials.

Figs. 54 and 55 give two longitudinal and two cross sections of trough cable conveyors. The speed of travel is 100 to 120 feet per minute.

Fig. 57. Angle Station of Cable Trough Conveyor.

Fig. 56 illustrates a complete installation of this type of conveyor, showing the two terminals in plan and elevation as well as a cross section through the conveyor.

Fig. 57 shows this type of conveyor fitted with metal troughing. It also illustrates the manner in which two such conveyors are driven at right angles.

Trough Cable Conveyor of the Jeffrey Manufacturing Co.—Cable trough conveyors may also be used as inclined retarding conveyors for lowering coal from higher to lower levels, work which as a rule is performed by means of a system of colliery tubs. The plant here illustrated is of special interest because it replaces the old tram system, and has several points of advantage in its favour. Its first cost is less, while it is simple and requires practically no power or attendance. In the plant illustrated in Fig. 58 the coal is discharged over the ordinary tippler at the head into a hopper from which it is fed on to the conveyor, which in this case is a Jeffrey wire rope with disc-shaped attachments running over special sheaves at the terminals and operating in a V-shaped trough. When the conveyor is loaded and working with a continuous feed, it acts as a retarder in keeping the coal from running away by itself. A small motor is generally necessary to start the conveyor, while when running with a full feed a brake is used to keep it in check. By this system coal may be carried to the shoots or cars below with but

Fig. 58. Retarding Cable Trough Conveyor at the Mines of the Logan Consolidated Coal and Coke Co., Matewan, W. Va., U.S.A.

little breakage, and at the rate of 100 to 140 tons per hour. In the plant illustrated the distance from the upper to the lower level is 500 feet. Formerly colliery tubs were

Fig. 59. General View of Meat Conveyor.

used, but as this system has proved a practical success in America, it will doubtless find favour in other collieries for work under similar conditions.

This plant was erected by the Jeffrey Manufacturing Co. of Columbus, U.S.A., for the mines of the Logan Consolidated Coal and Coke Co., at Matewan, W. Va., U.S.A.

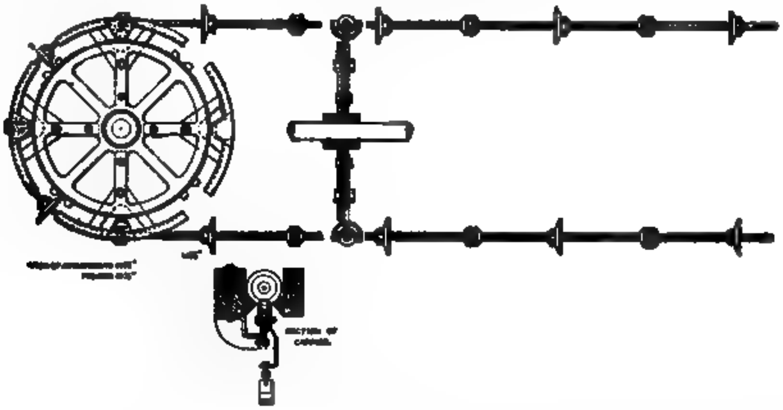


Fig. 60. Details of Meat Conveyor.

A modification of this type of conveyor is used for handling carcasses in slaughter-houses. A general view of this appliance is shown in Fig. 59, whilst Fig. 60 shows the detail of one of the driving terminals, and the construction of the conveyor itself. This conveyor consists of a steel cable to which are connected at regular intervals two kinds

of attachments, the smaller one being for the purpose of driving the rope from the terminal, whilst the larger and disc-shaped attachment is intended to engage and push forward the trolleys from which the beef and pork are suspended.

The illustrations explain themselves. Such a plant is at work at the packing house of John P. Squires & Co., Cambridge, Massachusetts, U.S.A., and was erected by the Steel Cable Engineering Co., Boston, U.S.A.

CHAPTER VI.

BAND CONVEYORS.

THE credit of this invention, at all events in its present form, is due to Mr Lyster, engineer of the Liverpool Docks, who in 1868 carried out a series of experiments on behalf of that body in order to ascertain what type of conveyor was most suitable for the mechanical handling of grain. The experiments were initiated on worm conveyors of different types, which, however, proved altogether inadequate for large granaries and silo warehouses, principally on account of their small capacity and the great driving power required. Mr Lyster then began to experiment with endless travelling bands, and after a few preliminary trials with small canvas bands, made further trials with a band 12 inches broad. This band was run at different speeds to ascertain the highest velocity at which such conveyors could be worked with safety and economy. It was also desired to practically test the most suitable speeds for different kinds of grain.

A speed of 8 feet per second was found to be the maximum for light grain, such as oats, while careful experiments showed that even bran and flour could be conveyed at this speed without such material being thrown off the band by the resistance of the air to its passage. A speed of about 9 feet per second was found suitable for heavier grain, such as Indian corn, peas, &c. The capacity of this 12-inch band when fed to its fullest extent was found to be about 35 tons of grain per hour, the band then travelling at the speed of 8 feet per second.*

Mr Lyster found by his experiments that grain had no tendency to fall off the band, and that even single grains when placed near the edge remained in position while passing over the carrying rolls at the speeds mentioned.

At the present day band conveyors are used chiefly for conveying grain, but in many cases also serve for the conveying of heavier materials. These conveyors consist of bands of canvas, or of woven wire, or of indiarubber with insertion, and other bands known as balata belts.

These endless bands run over terminal pulleys, and are in addition supported on their way by a series of rollers, which are more frequent on the loaded than on the empty strand.

Such conveyors are usually fitted with some kind of tightening gear to keep the belt in tension.

Like other mechanical inventions, the band conveyor had to pass through a period of disappointments. It was feared that a flat band would spill the grain, and the supporting rolls were therefore hollowed out in the middle to give the band the form of a trough. This was all right as far as conveying was concerned; but on the other hand, the bands employed, which were composed of cotton webbing covered with rubber, wore out in a very short time, because, owing to the varying diameters of the curved

* See Proceedings Mech. Eng., August 1869.

roller and the consequent variation of the circumferential velocity at different points of the roller, a grinding action was set up between the rollers and the band, the velocity of the latter being of course the same for the whole of its width. This grinding action destroyed the bands. Later on further trials confirmed Mr Lyster's experiments, showing that grain could be conveyed in all security on a perfectly level band provided it were properly delivered thereon, *i.e.*, at the same speed as that at which the band was travelling. At the present time band conveyors for grain mostly run perfectly flat, except at the point or points where grain is fed to them; but at these points two separate cylindrical curving rolls are applied which slightly hollow the band for a few feet, and then allow it to lie flat again on its supporting rollers.

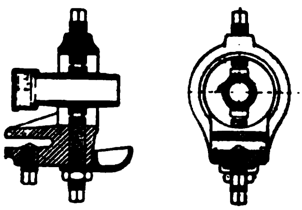


Fig. 61. Guide Roller Bearing for Band Conveyor.

These supporting rollers are 4 to 6 inches in diameter, and are sometimes made of wood, but more often consist of steel tubes to which spindles with conical end gudgeons are secured. These gudgeons generally run in suitable bush bearings, which should be well lubricated.

A more elaborate bearing is the one illustrated in Fig. 61. It consists of a neat cast-iron bracket which can be clamped to the angle-iron framework of the band conveyor without necessitating the drilling of holes in the same. The bearing is adjustable up and down, while one end is formed into a Stauffer lubricator, which can be filled with a viscous lubricant.

This bearing being long and movable, will adjust itself to the position of the spindle,

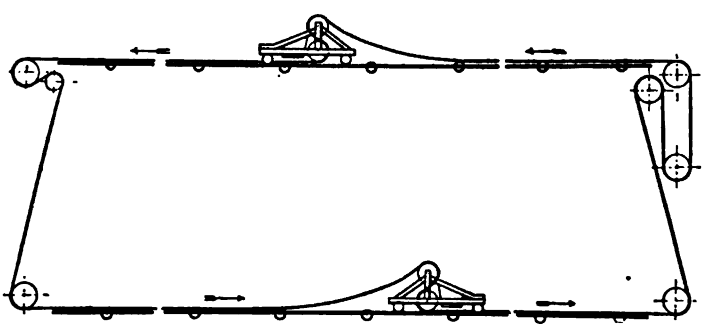


Fig. 62. Band Conveyor suitable for conveying on both Strands.

so that friction should be reduced to a minimum. The appliance is also fitted with a removable cup for the reception of any surplus lubricant.

Supporting rollers are fitted at intervals of 6 feet to the upper or working side of the band, and at every 12 feet on the lower or return strand. Sometimes it is desirable to use both strands of the band for conveying purposes, in which case the supporting rolls for the lower strand must be as close together as at the top. Moreover, the terminal pulleys must be larger than usual. This will give the two bands a greater distance from each other, and will allow sufficient space between the strands to spout the feed in, and out again at the other end. The two strands can be run any distance apart by using two additional guide pulleys for the terminals as shown in Fig. 62.

In such a case one band might run along the top floor of the granary whilst the other travelled along the bottom. Throw-off carriages are indicated on both top and bottom bands.

A supporting roller for a grain conveyor is shown in Fig. 63.

Sometimes curving rollers are used at intervals in addition to the point or points where the conveyor receives its feed. The tightening of a band conveyor is effected in a similar manner to tightening on elevators,* *i.e.*, by means of two screws which push or pull the two pedestals of one terminal pulley further away from the other terminal; but as such an appliance does not admit of great latitude, it is insufficient for very long conveyors. In such cases the tightening gear would consist of a pulley, held in tension by weights, over which the belt passes. This tightening pulley can be placed at any point on the return strand of the belt, but is generally situated at the end opposite to the driving end of the conveyor.

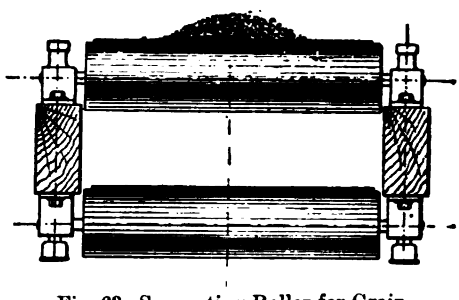


Fig. 63. Supporting Roller for Grain Conveyor.

Fig. 64 shows a tightening pulley as used at the terminal.

In Fig. 65 is illustrated a form of tightening pulley which can be applied to any part of the returning band.

It is undoubtedly preferable to use tension screws for tightening the band if it be possible, and in cases where throw-off carriages with fixed pulleys are used, and where

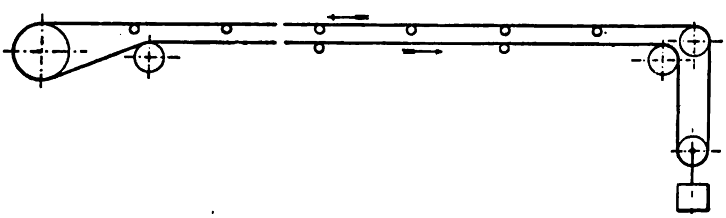


Fig. 64. Mode of Tightening Band Conveyor at Terminal.

the conveyor is not too long, there is no objection to this course; but if throw-off carriages of the swivelling type are used, as in the case where the material has to flow on the band past the throw-off carriage, it becomes necessary to have tightening gears with

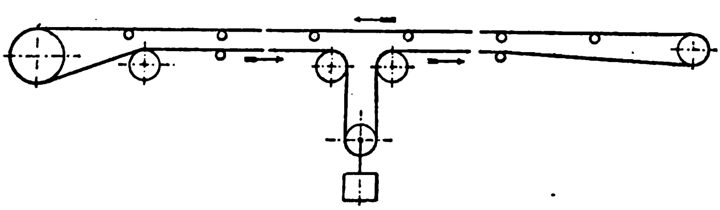


Fig. 65. Mode of Tightening Band Conveyor on any Part of Return Strand.

weighted pulleys. As to the allowance to be made for tightening belts, that must greatly depend on the quality of the band. A good conveying band with a breaking strain of say 400 lbs. per ply per inch width requires an allowance for tightening of 4 per cent. This would indicate that with a band of good quality even of great length the screw tightening gear can be employed if otherwise suitable.

* See tightening gears, page 90.

The tight side of the band is the one that should by preference be used for conveying, as this side is always in a flatter condition than the other.

To withdraw the feed from a band conveyor at any intermediate point a throw-off carriage is employed, the credit of which device is largely due to the experiments of Mr Lyster. To remove the grain he made trials with several contrivances, including air blast and brush devices driven from the band itself. Both methods, however, gave but indifferent success. In both cases a most objectionable amount of dust was raised. Moreover, the friction of the brushes on the band proved in time injurious to the latter. The idea then

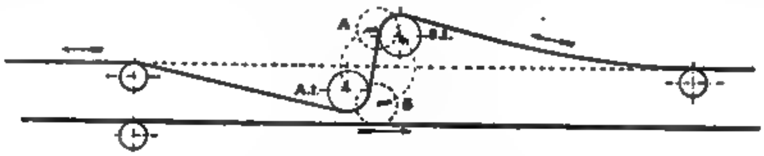


Fig. 66. Diagrammatic View of Throw-off Carriage.

occurred of diverting the stream of grain by means of an upward deflection of the carrying band, thus casting the grain clear of the band and into the air for a short distance, so that it could in falling be caught and led off through the spout on either side as required. The device consisted in principle of two guide pulleys which in most cases can be turned round a common centre by means of worm and worm wheel. When out of use one guide pulley is above and one below the band, which runs through between them but without touching them. If delivery of the material is required at a certain point, the throw-off carriage is pushed into position and the guide pulleys are turned round the common centre in the direction of the arrow, so as to raise one part and lower the other

Fig. 67. Adjustable Throw-off Carriage Designed for the Liverpool Docks.

part of the band as shown in Fig. 66. In this illustration the dotted circles A, B, indicate the guide pulleys when out of use, while those in full line A_1, B_1, show the position of the pulleys when the throw-off carriage is in use.

As soon as the grain arrives at the throw-off carriage it leaves the band by its own momentum, and is received in a hopper which forms part of the apparatus. It is then spouted sideways clear of the band to its destination.

This arrangement for withdrawing the grain from the band proved a complete success, and has been universally adopted. The throw-off carriage designed for the use of the Liverpool Docks in 1868 was probably the first of these devices, and is shown in Figs. 67 and 68.

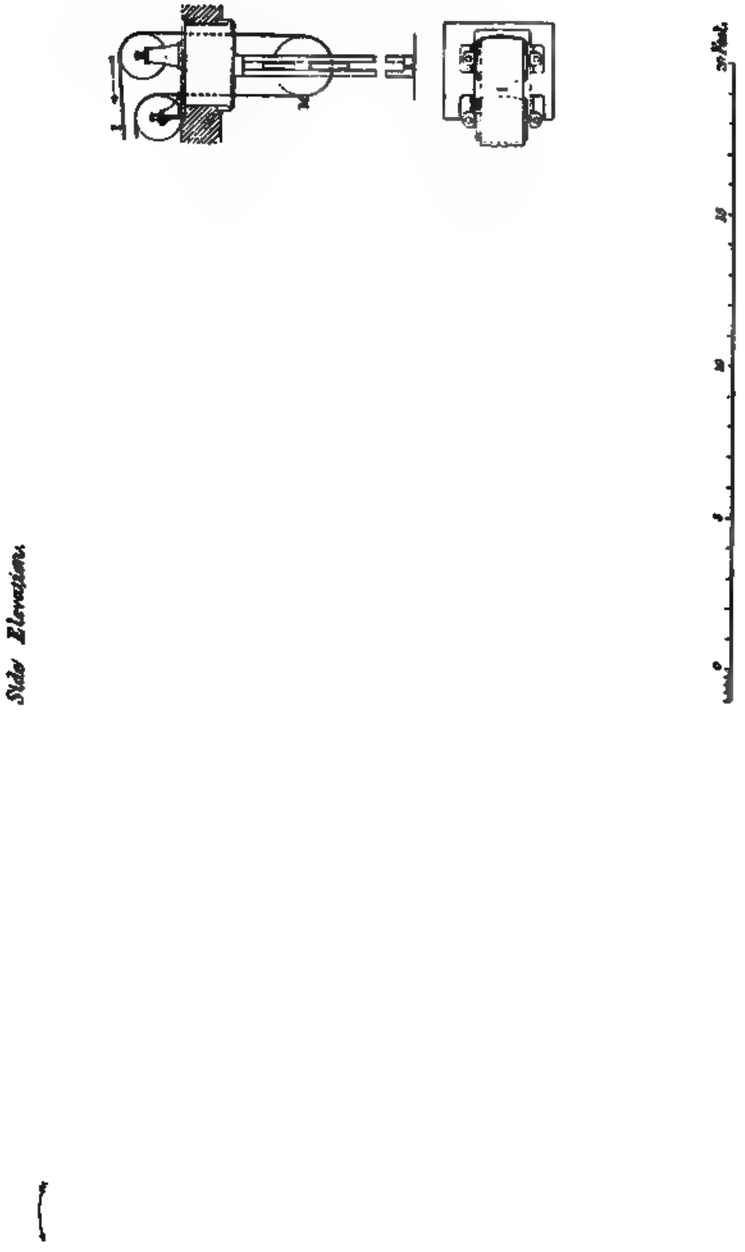


Fig. 68. General View of Band Conveyor with Adjustable Throw-off Carriage Designed for the Liverpool Docks.

It consists of a pair of wrought-iron rollers centred in gun-metal bearings in a rocking frame which is hung in a movable carriage running upon the top of the timbers of the wooden framing that supports the travelling band II. The carriage is moved to any position along the length of the band where the grain is required to be discharged, and is there secured by wedges and clamping screws.

The rocking frame is rotated in either direction by means of worm and worm wheel so as to bring the pair of rollers into action in the proper position for throwing the grain off in the same direction as that in which the band I is running, while the rollers are turned back into a horizontal position so as to be clear of the band when the carriage is required to be moved to any other point on the length of the band. A curved spout is attached to the carriage for receiving the stream of grain in its fall and leading it off on either side of the band I.

The throw-off carriage shown in Fig. 69 is of a very simple kind without adjustment. It has a clamp by means of which it can be secured in its position. The diagram shows also the receptacle for the grain and the alternate outlets on either side with valve arrangements.

This appliance having no means of adjustment, when not in use, must always be

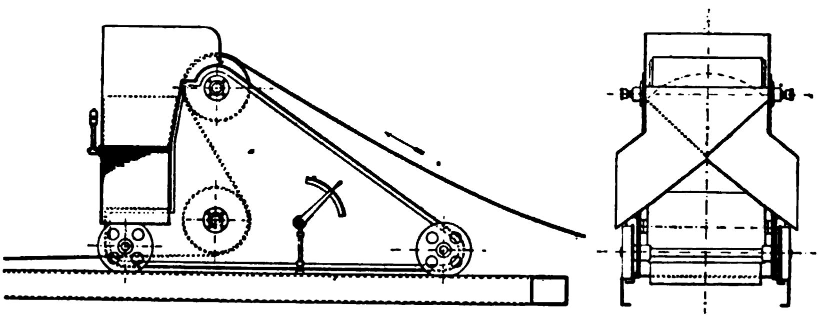


Fig. 69. Non-adjustable Type of Throw-off Carriage.

moved to the terminus. It is also sometimes made with a third outlet which delivers the grain back again on to the band if intermediate delivery is not required. In such a case the position of the carriage when not in use is immaterial, as the grain can proceed through this third outlet uninterruptedly.

Band conveyors can be fed without any difficulty; but it has been found necessary to slide the grain upon them from the feeding hopper through a spout rather less than half the breadth of the band and set at an incline of 42½ degrees to the horizontal, so as to give the grain falling upon the band a horizontal velocity nearly equal to that of the band.

It is very important to regulate the feed of the band if only to minimise wear as much as possible, especially when conveying coal and other sharp-edged material. The material should not strike the band vertically, whilst the height from which it falls must be reduced as much as possible so as to allow of a gentle drop.

As the flow by gravity of grain of various kinds and in varying condition through a spout differs considerably, it is advisable to place a pair of oblique side rollers at the point where the grain falls upon the band as already mentioned, for the purpose of preventing the tendency of the grain to spread. In passing heavy quantities of grain along the band for a considerable distance it has also been found expedient to apply at intervals

pairs of these oblique side rollers, which are carried in movable frames which can be set at any required spot.

All conveyors which are intended for intermediate delivery by means of an adjustable throw-off carriage must be fitted with tightening gears as shown in Figs. 64 and 65, because the use of such throw-off carriages necessitates additional length of conveyor band which must be disposed of whenever the carriage is out of use. These tightening arrangements provide suitable accommodation for such extra length of band.

The speed at which band conveyors for grain are run varies from 400 to 600 feet per minute. The former speed is for oats and grain which contains a quantity of chaff and hulls that would be blown off the band at a speed exceeding 500 feet. Wheat and barley are generally conveyed at a speed of 500 to 550 feet; while maize, beans, and heavier seeds are conveyed at the maximum speed of 600 feet per minute.

The approximate economical capacity in tons of band conveyors from 6 to 24 inches wide is given in the following table for different speeds:—

CAPACITY OF BAND CONVEYORS FOR GRAIN.

Width of Band.	Speed of Band in Feet per Minute.		
	400	500	600
Inches.	Tons.	Tons.	Tons.
8	6	7	8
10	8	10	12
12	18	20	22
14	26	30	34
16	36	40	44
18	45	50	55
20	60	65	70
22	70	80	90
24	90	100	110

The power required for band conveyors for grain is less than with any other conveyor. An 18-inch band at 500 feet per minute would convey 50 tons of grain per hour, and if 100 feet long would consume 4·5 HP.

Band Conveyors for Heavy Material such as Coal, Coke, Minerals, &c.—These conveyors are very similar to those previously described, with this difference, that the fittings throughout are much more substantial. To begin with, the bands themselves are stronger, so as to bear the greater weight, and also the severe strain at the point where the feed is received. Special attention is paid to the centre portions of bands which are subjected to the greatest wear and tear; they are usually made of insertion covered with indiarubber—at least the portions which run on the rollers—while the top which carries the load is solid indiarubber, extending for nearly half the thickness of the band in the middle, and tapering off towards the edges.

Such conveyor bands will resist a strain of 3 tons per square inch. They are subjected to an enormous pressure, and are stretched by means of special plant in order to minimise further stretching. In some cases balata belts are used. These consist of cotton soaked in balata so as to be proof against damp. Such bands are not so expensive, but are less durable than rubber bands.

Whereas with grain conveyors curving rollers are only occasionally used, with these conveyors they are used for the entire length of the loaded strand, forming it into a trough-shaped groove. This is effected by fitting each support with two or three cylindrical rollers for carrying the top strand.

Fig. 70 shows one of these supports for both top and bottom band, consisting of six rollers, this being the design of the Robins Conveying Belt Co. of New York.

The bottom band is sometimes supported by single rollers, as in the case of grain conveyors.

As there is sometimes a tendency for the band to make a side movement on its rollers, so that the centre of the band is not in the centre of its supports, the employment of smaller rollers for preventing this is often necessary.

The accompanying illustration, Fig. 71, represents a form of band conveyor constructed by the Berlin Anhaltische Maschinenbau Aktien-Gesellschaft for conveying coal. The illustration shows clearly the type of tightening gear employed. It also gives the main drive with its two tightening pulleys in plan and elevation, the throw-off carriage, and a cross section through one of the termini, as well as one intermediate section through the band.

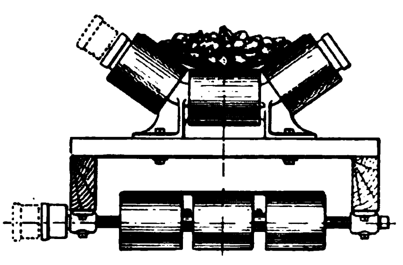


Fig. 70. Support for Band Conveyor of the Robins Belt Conveying Co.

The illustration, Fig. 72, shows a similar band conveyor, the design of Herr Merz, of the Gas-works, Cassel, Germany. This conveyor was also built by the above-mentioned firm. The special features of this latter are that it can be shortened or lengthened at will, and also made portable. As shown in the illustration, the different lengths of the framework are joined together by wedges, while the whole can readily be taken to pieces, shortened or lengthened.

The illustration, Fig. 72, shows the whole conveyor in plan and elevation. It also gives details of the terminal and the intermediate supports.

If the life of a belt is to be prolonged, it is most important that no damp should penetrate through cracks to the inside. It is also necessary to see that the edges do not in any way cut against any hard substances, otherwise the layer of rubber will very soon be worn off, and the woof of the belt laid bare. Generally speaking, belts must be very carefully handled, and kept as far as possible free from damp.

It may be noted that bands made of woven wire are sometimes used in connection with coal-washing plants. As these bands have much in common with belts of textile material, they may be handled in much the same way, and run at a high speed, nearly 10 feet per second. To ensure a proper grip, the driving terminals must be faced with leather or made of wood. Such bands are not very durable, their tendency to stretching and their relatively high price being against their more frequent adoption.

The principal advantages of band conveyors are:—The small amount of power required to drive them, small wear and tear, noiseless working, and non-injury to material during the process of conveying.

The disadvantages are:—The feed cannot be withdrawn at intermediate points without the use of a more or less cumbersome throw-off carriage, while in most cases the feed will have to be stopped if the delivery of the band is to be changed to a different point. There is one further drawback, and that is this—a great many small bearings have to be oiled and kept in repair, and as the rollers make 150 to 600 revolutions per minute, these require considerable attention.

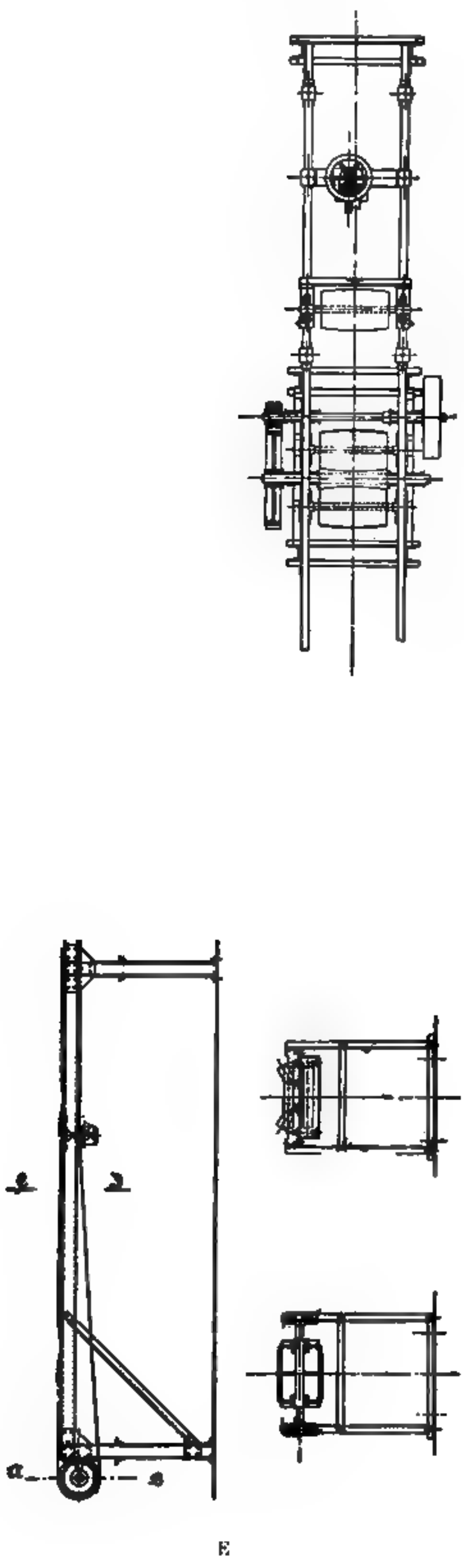


Fig. 71. Coal Conveying Plant of the Berlin Maschinenbau Aktien-Gesellschaft.

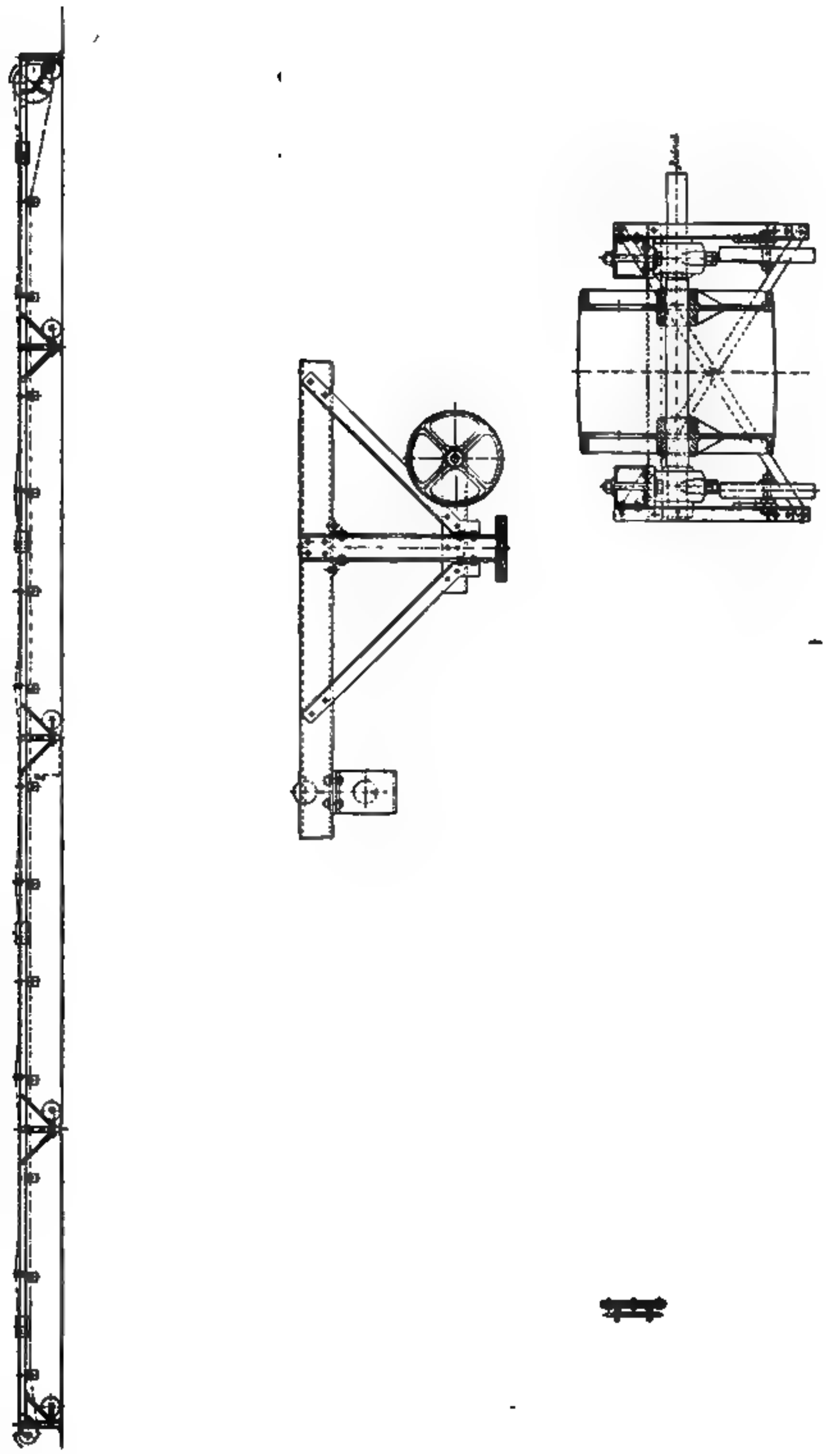


Fig. 72. Portable Band Conveyor.

With regard to the speed of these conveyors when handling minerals, there is a wide difference according to the nature of the material. It is not so much the specific gravity which determines the speed of these conveyors as the size of the pieces to be conveyed.

The best speed for large pieces is 150 to 250 feet per minute, and the speed increases

Fig. 73. Sack Conveyor at the Mills of Messrs Leetham & Sons, York.

in proportion for material of a smaller size to a maximum speed of 700 to 750 feet per minute.

Band conveyors may be used to convey uphill at any inclination, up to 24 degrees, without affecting the capacity.

The following table gives the approximate capacity for coal in tons per hour of different sized belts, with their respective speeds, and the horse-power required for lengths of 100 feet:—

CAPACITY OF BAND CONVEYORS FOR COAL.

Width of Band.	Speed.	Capacity for Material weighing 100 lb. per Cubic Foot.	Size of Material.	Brake HP. for Conveyor 100 Feet long.
Inches.	Feet per Minute.	Tons per Hour.		
12	150 to 350	10 to 35	From 2-inch cubes to dust	3·2
18	150 „ 450	50 „ 150	„ 4-inch „ ¾-inch cubes	4·8
24	150 „ 600	150 „ 250	„ 6-inch „ 1-inch „	6·0
30	150 „ 700	400 „ 800	„ 7-inch „ 2-inch „	7·6
36	150 „ 750	500 „ 1,000	„ 9-inch „ 2-inch „	9·2

The horse-power given in this table is for horizontal belts. If the belt is inclined, the power varies in proportion.

Ridgway's Belt Conveyor.—The latest innovation in belt conveyors appears to offer some advantages over the existing types. It was brought out by the Ridgway Belt Conveyor Co. of New York.

It consists of two bands running on top of each other instead of the ordinary single band. The guide pulleys are cylindrical, similar to those shown in Fig. 63, and the band is, therefore, running flat; to this inner band are fixed at intervals concave wooden blocks, on which the upper band rests and forms a trough. With this arrangement the lower band is scarcely subjected to any wear and tear, as it never comes in contact with the material; only the upper band, therefore, requires renewing at a comparatively small cost, as the two bands are each only about half the thickness of the single bands now in use.

In order to show that band conveyors are used not only for conveying grain and other material in a uniform stream, but will also serve to convey larger bodies intermittently, the sack conveyor installed at Messrs Leetham & Sons' Flour Mills, York, is here illustrated.

Fig. 73 shows the conveyor loaded with sacks as they are taken from the warehouse to the loading platform at the railway station.

Fig. 74 shows the delivery terminal with one sack on the point of being discharged. The sacks are delivered from the end of the conveyor at a sufficient speed to slide down the shoot and over an inclined table, practically into the man's hands ready for stacking in the waggon. There is another siding on the other side of the conveyor, and when the table is reversed the sacks slide over for the purpose of loading into another truck on that side. This unloading process can go on without being interrupted, because whilst one truck is being loaded the full one can be removed and an empty one put in its place.

With this conveyor twelve railway waggons can be loaded in one hour by two men.

The conveyor itself is a band of the ordinary construction, with the exception that it is built rather more substantially, and that the supporting rollers are 18 inches apart

Fig. 74. Sack Conveyor Delivering to Railway Trucks from Messrs Leetham & Sons' Mills, York

instead of 6 feet. The conveyor is altogether 350 feet long, and the band is 26 inches wide.

This installation was the work of Messrs Spencer & Co. Ltd., of Melksham.

Portable Band Conveyor.—The Robins Conveying Belt Co. build a portable band conveyor, self-contained, with a motor attached, in a light steel frame. The motor may be worked by steam, pneumatic or electric power. One of the terminals is fitted with tightening gear and the whole frame is mounted on small wheels, so that it can readily be put in position wherever it may be required. Several lengths can be joined together if necessary, or they can be used in such a way as to deliver one upon the other, as shown in Fig. 75, which represents different stages when cutting a tunnel, and the use of three or more conveyors for the purpose of removing the debris. The longitudinal section and the corresponding cross sections through the tunnel show the progress of the excavation. The conveyor itself is represented in the cross sections by a straight and a curved line for the lower and upper strand of the belt. These conveyors can of course be used for numerous other purposes, such as mining, quarry work, &c.

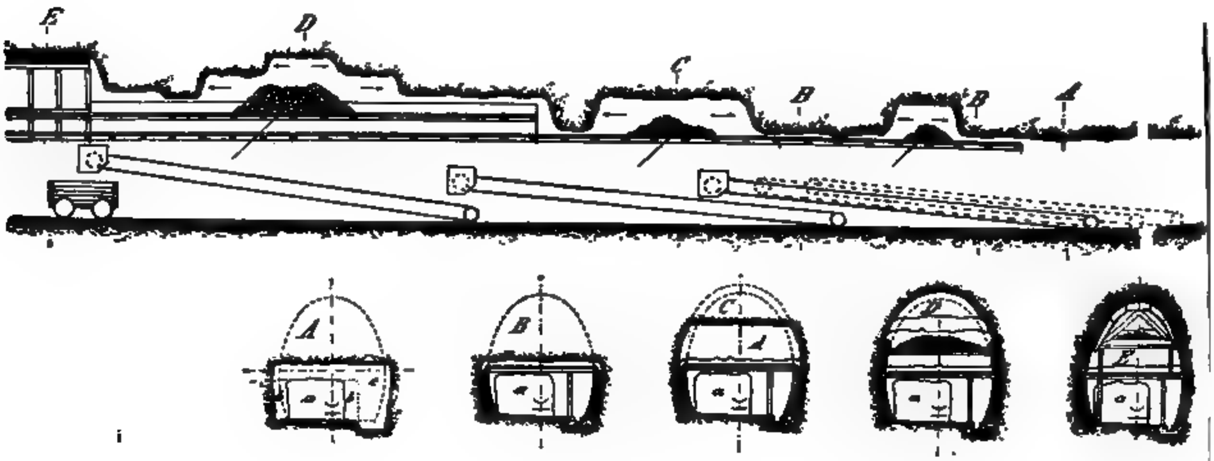


Fig. 75. Portable Band Conveyor of the Robins Conveying Belt Co.

CHAPTER VII.

METAL BAND CONVEYORS.

It is evident that there must be a point at which band conveyors of textile and similar material can no longer be effectively used, and that point is reached when sharp and cutting material has to be handled. In such cases it is usual to employ endless bands, so to speak, composed of a series of iron plates connected to suitable chains running beneath the plates. Conveyors of this type are used in the same manner as band conveyors of rubber or cotton. Of course the iron plate conveyor is a more cumbrous appliance, travels at a much lower speed, and has a much more restricted field of usefulness than a textile band conveyor. The sections of iron band conveyors are attached to chains either of cast or wrought iron. The former are more frequently used because they can more readily be shaped to suit any special work, and all kinds of carrying plates can easily be fitted to them.

Ordinary Ewart chains are not much used, because they wear rapidly, and are very liable to breakages when used for such heavy work; and though broken parts can no doubt be readily replaced, yet an accident to a conveyor must cause stoppage and delays. The form of conveyor more generally used is one in which the links are of malleable cast iron and are joined together by hardened steel pins. Where such conveyors are required for extra heavy and especially rough work, or where stoppages would be most detrimental, it is usual to use wrought-iron chains, the links of which may either be short after the style of the Gall chain, or consist of long forged links of the same length as the width of the plates.

This type of conveyor generally delivers only at the end; but should intermediate delivery be required, a delivery scraper is fixed across the band at an angle of about 45 degrees, which scrapes the whole or part of the feed of the band into a shoot. If the intermediate delivery is not confined to one or more fixed points, and if it be desirable that delivery should take place at any point in the length of the conveyor, a scraper is mounted obliquely on a suitable carriage which can be moved into any position for the purpose of intermediate delivery.

The withdrawing of the feed from such a continuous steel band has this drawback, that the frequent joints in the band produce a rasping action on the material during the process of scraping off, which is detrimental with such material as friable coal, and causes sufficient loss to make such an appliance impracticable.

Figs. 76 and 77 illustrate conveyors of this class. The convexity of the links in Fig. 76 gives them great strength, and is specially intended to facilitate the delivery of the material as the band reaches the terminal pulley.

In some of the best constructions each short section of trough or band is fitted with a narrow curved strip which is either part of the section or is riveted in such a position as to make a leakage between each two sections impossible, as the strip is fixed just over the butt joint of the two sections. This strip is so curved as to allow the sections to bend freely when passing the terminals.

In Fig. 77 the surface of the plates is not convex but flat, with the exception of a slight curve at the joint just mentioned to allow of the plates interlocking.

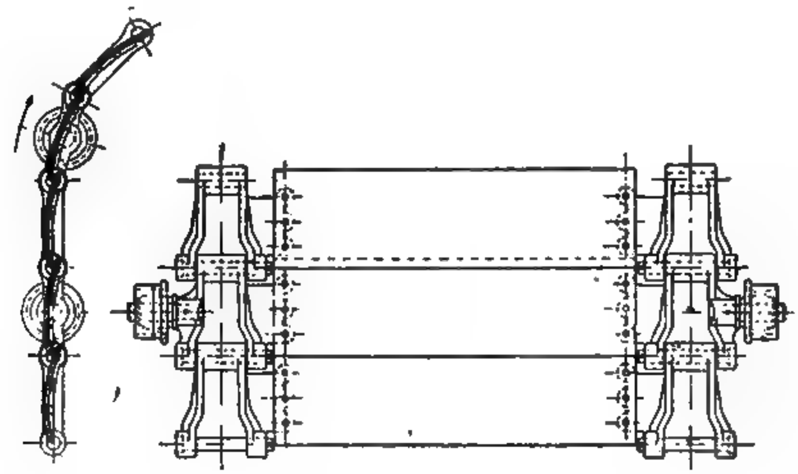


Fig. 76. Type of Metal Band Conveyor.

Conveyors of this type are often used as picking tables for sorting coal and other materials whilst they are being conveyed (see page 78). They also take the place of

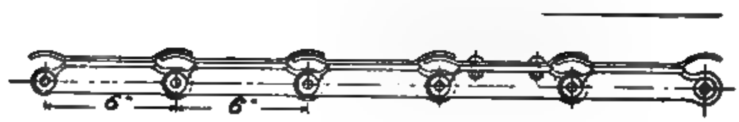


Fig. 77. Metal Band Conveyor.

ordinary band conveyors, where the nature of the material to be conveyed would injure a rubber or textile band.

The belt is often supported by stationary rollers underneath. In more modern belts (see Fig. 76) the rollers are attached to the links and travel with them, an arrangement

which has the advantage of economising the driving power. The screeching of belts of the ordinary type caused by the edges of the belt rubbing on the side angles is avoided. Moreover, the points of the support being fixed relatively to the belt, there is none of the irregular up-and-down motion sometimes met with on inferior bands, and the whole action is much smoother.

Fig. 78 represents a metal band conveyor built by the Steel Cable Engineering Co., which is used for the purpose of sorting chips in wood pulp mills. These conveyors very much resemble colliery picking bands, and beyond the fact that the framework is of timber, they might be used for the same purpose.

Every second section of the band has its own guide pulleys, which run on angle-iron

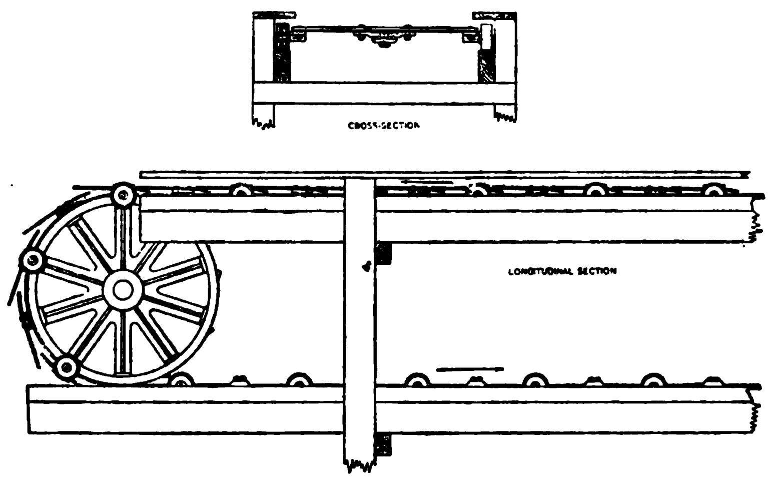


Fig. 78. Conveyor for Sorting Chips in Wood Pulp Mills.

bars in the side of the framework, as seen in the cross section. The different plates overlap each other so as to make leakage impossible.

Unlike other conveyors of this type here mentioned, the one in question is driven by cables instead of by chains.

The tightening of these conveyors is effected in a similar manner to that of band conveyors, and the speed at which they run is 60 to 120 feet per minute.

Metal band conveyors are principally used for conveying coal, and have the great advantage of handling it so gently as to avoid breakage, provided of course that the delivery is at either terminal. There may be one drawback to the use of these conveyors beyond the keeping in repair of numerous small wearing parts, and that is that the driving gear must always be at the delivery terminal of the conveyor.

* See Tightening Gears, page 90.

CHAPTER VIII.

PICKING BELTS OR TABLES WITH OR WITHOUT LOWERING ENDS OR SHOOTS.

PICKING belts or tables are used for removing stones and other impurities from coal and other minerals. They have also a place in cement works, where they are used for the purpose of picking the clinkers over.

Picking belts or tables of the construction of the ordinary band or metal band conveyor have been described in the foregoing pages, so that it is not necessary to describe their construction; but it may be useful to set forth the manner in which these appliances and their accessories are used.

In width, picking belts may vary from 3 to 5 feet; 4 feet 6 inches will be found a very suitable width if picking is to be done from both sides.

A great diversity of material is used for picking belts; but canvas, indiarubber, or woven wire is seldom used, at least not for the heavy work of dealing with South Wales and other large coal, where a hard surface is absolutely essential as well as substantial framework and carrying arrangements.

A very important matter is the discharge of the coal from the belt. If a fall of any depth is permitted, breakage results, and to some extent the result of the screening is vitiated. It is on this account that in some cases the picking belt has been provided with a jib extension of which it is the special function to load the coal into waggons. If a separate loading device is used, a second fall seems to be unavoidable as the coal passes on and off the lowering band.

The Koch belt is the nearest approach to a flexible steel band, and if it were a thoroughly practical appliance it would be an ideal picking belt. It consists of separate plates curved so as to form segments of the terminal drums (see also Fig. 76) carried upon double link chains and provided with rollers. The curvature given to the plates makes them very stiff transversely, but unfortunately the belt cannot be so made that the discharge shoot can be closely applied to the nearly cylindrical end. Hence if placed high up to prevent any fall of the coal, the smaller particles will fall through the gap. The usual form of belt composed of flat plates, attached to two or three link chains according to the width of the belt, has this drawback, that the delivery over the end can only be made by setting the receiving shoot well below the centre of the terminal drum, on account of the backward and forward motion on the end, according as the flats or the angles of the polygon drums are presented to the receiving shoot.

To overcome this difficulty, Howe's delivery shoot, Fig. 79, has been introduced, and has proved fairly efficient. The shoot A is so suspended as to have a tendency to lie close up to the belt terminus, and two upturned horns B at either side are kept in contact with the conveyor plates, and serve to make the shoot follow and conform to the motion of the plates.

In the illustration, the shoot A is shown as a short screen to remove any fine coal made after the coal leaves the first screen. This improvement is occasionally met with.

As mentioned elsewhere,* in some instances the picking band itself is extended to

* See Cornet conveyor, page 78.

form a jib end which can be either raised or lowered into a suitable position, so as to lower the coal into waggons. This plan has two objections. In the first place, the jib must be long enough to prevent the coal from rolling off it. As a consequence, the back portion of the waggon cannot be conveniently reached, and when starting to load, the coal has to fall at least the depth of the waggon, as the return belt on the under side has

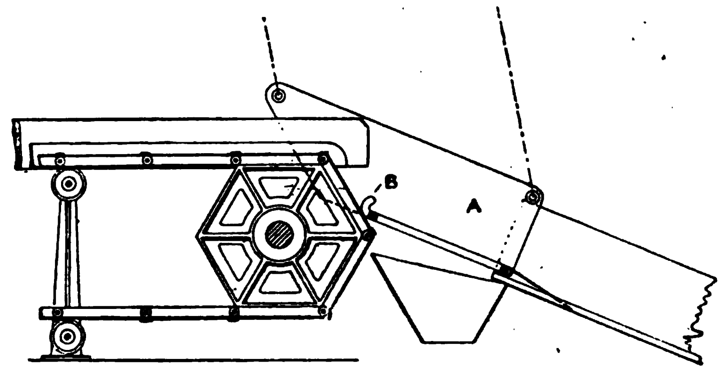


Fig. 79. Howe's Delivery Shoot.

to clear the side of the truck. The terminal drum of necessity occupies a considerable space, unless the belt is composed of very narrow plates and short links. In the second place, the return belt on the same side has to make a bend forming an obtuse angle at the top of the jib end, and if the plates have a normal amount of lap they are very likely to be stripped off the links. This latter difficulty may be met by making the links so that the centre of the pins coincide with the line of the plate (see Fig. 80).

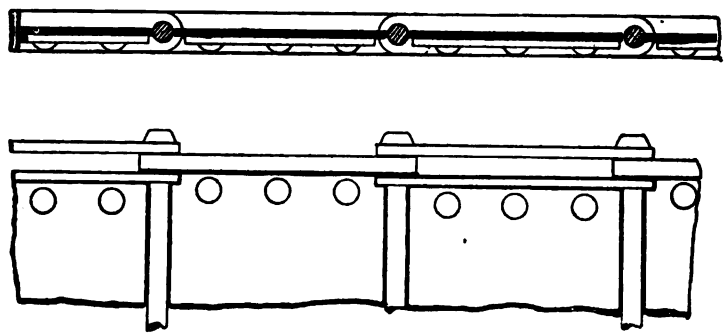


Fig. 80. Band which will Bend in either direction.

In this case the belt bends equally well in either direction; but wear and tear in the joints will gradually cause gaps between the plates and the pins through which small coal may drop, this being a great objection to an otherwise good construction.

A much better plan is the provision of a separate lowering belt with shorter links, so that terminals of smaller diameter can be used, which may be four-sided only. This belt may be provided with a plain shoot in which the chains travel with the angle bars between them at intervals, the angles serving to prevent the coal from running down the belt or shoot. Even under these conditions the hinder part of the waggon cannot be reached, and at the front end some drop of the coal is inevitable, for, if the cross pieces are steeply inclined, the larger fragments of coal will topple over them, while if they

are made higher to prevent this, they require more room for clearing the truck on the under side.

A vertical arrangement would appear to be the most suitable. Wrightson's coal shipper,* Rigg's lowering device,† and Soar's loader ‡ may be cited as suitable devices for loading work.

A further step towards the solution of the problem is seen in Fig. 81,§ which represents an arrangement devised by Mr S. A. Everett for loading coal down a shoot. The return chain here rests above instead of below the shoot, and the obstructing pieces, made for lightness sake of corrugated plate, fold up on the return side, so as to economise space. By a kind of cam the flaps are made to open gently as they come over the top

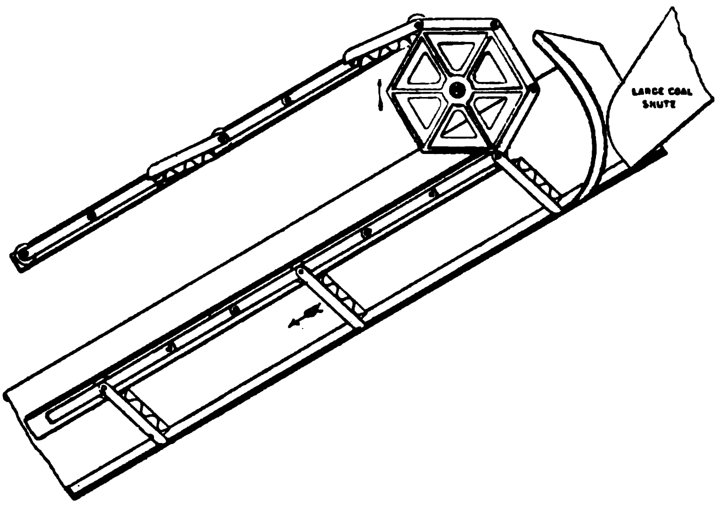


Fig. 81. Everett's Loading Device.

tumbler, and being deep, they permit the shoot being lowered to a very steep incline without allowing the coal to fall.

For the use of the swinging conveyor as a picking and lowering band, see pages 85 and 89.

For loading coal down an incline by gravity either on to or from conveyors, ordinary wrought-iron shoots are generally used, and they should be at such an incline that the coal will only just slide down, thereby avoiding breakage, and keeping the delivery as uniform as possible.‖

It may therefore be of interest to give a few of the inclines at which coal will easily descend the shoots. The incline is given in inches per yard of shoot.

Mixed coal, large or small, as emptied from colliery tubs	$15\frac{3}{4}$	in. to the yard.
Cobbles	$14\frac{1}{2}$	„ „
Nuts	15	„ „
Slack or small coal	19	„ „
Cannel coal	$14\frac{1}{2}$	„ „

* For description of Wrightson's coal shipper see page 364.

† Rigg's automatic lowering device, page 363.

‡ Soar's loader, page 369.

§ For description of loading devices see *Iron and Coal Trades Review*, 6th April 1900.

‖ For spouts and shoots see page 20.

CHAPTER IX.

THE CONTINUOUS TROUGH OR TRAVELLING TROUGH CONVEYOR.

This conveyor forms, as it were, a link between the band conveyor and the vibrating trough conveyor, and is practically the same as the metal band conveyor, with this

Fig. 82. Type of Continuous Trough Conveyor.

exception, that each section has its sides turned up to form a channel as is shown in Fig. 82.

The endless trough travels over two terminal pulleys, one of which is adjustable to take up the wear in the joints of the chain.*

The sections of trough are also frequently fitted with small supporting rollers which

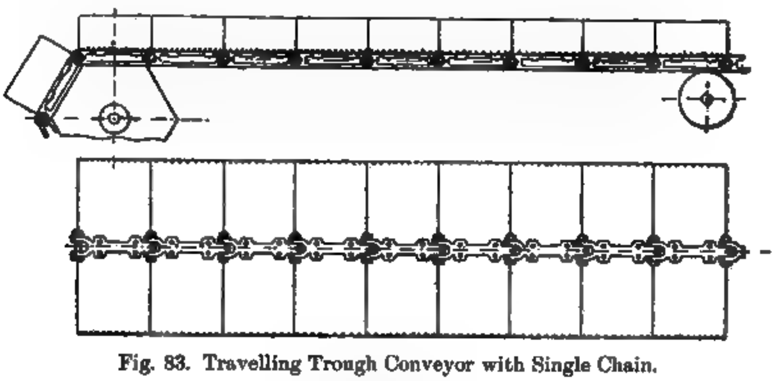


Fig. 83. Travelling Trough Conveyor with Single Chain.

run on angle bars in the same manner as metal band and push-plate conveyors. These travelling trough conveyors have this advantage over push-plate conveyors, that they take less power and cause less breakage to the material. With this type of conveyor, however, intermediate delivery is out of the question.

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* See Tightening Gears, page 90.

Fig. 83 shows a portion of such a travelling trough conveyor with single strands and hexagonal terminals, which explains itself. This class of conveyor can also be used for small inclines without loss of capacity—inclines of 15 degrees being quite permissible. In fact it may be effectively used to convey up inclines of from 15 to 45 degrees, but in such a case the sections of the conveyor are provided with projections which prevent the material from sliding back (see pages 104 and 105).

The speed of travel is 60 to 120 feet per minute, or somewhat less than that of push-plate conveyors. There seems, however, to be no reason why they should not run at the same speed. The capacity can easily be found by multiplying the area of the trough by the speed of travel.

A form of conveyor which differs materially from any hitherto described is the Cornet conveyor shown in Fig. 84.

This conveyor is used in connection with coal handling plants for loading and at the same time sifting coal. In this case the material to be conveyed is carried not on iron plates, but on a grating of round iron bars which are fastened at both ends to the two driving chains. The idea is to carry the large coal on the grating in order to screen out through the apertures such small coal as may be mixed with it. The coal falls direct from the screen on to the band, receiving a further screening as it passes

Fig. 84. Cornet Conveyor with Lowering Jib End.

along in a horizontal direction, and is then loaded directly into the railway trucks. To reduce as much as possible the fall of the coal, the delivery terminus of the band is made with a jib end, and can be raised or lowered by means of a small winch and chains according to the level of the coal in the truck. A counterweight is used to balance the weight of the movable end.

To every other link of the chain are fastened iron buckets which serve to prevent the coal from falling on the sharp inclined end of the conveyor, and so prevent breakage of the material. These buckets also serve to collect the small coal which has fallen through the bars as the chain goes back empty, scraping it together after the manner of a push-plate conveyor. For this purpose the ends of every other scraper bucket are deepened somewhat so that only half the buckets act as scrapers.

This apparatus is driven from a hexagonal terminal which is mounted, together with its countershaft, in adjustable brackets, for the purpose of tightening the band. The other terminal is only four-sided so as to save headroom.

Each link of the conveyor is fitted with a pair of small rollers which run in grooves.

CHAPTER X.

VIBRATING TROUGH CONVEYORS.

This is the latest type of conveyor, and consists of troughs which receive the material to be conveyed at one end and deliver it at the other end by means of a succession of suitable backward and forward movements of the troughs. It may therefore be classed with the two previous types, *i.e.*, the band and the travelling trough conveyor, as in all three conveyors the material is, so to speak, conveyed in the trough without the use of a stirring or pushing agent, as is the case with worm, push-plate, and

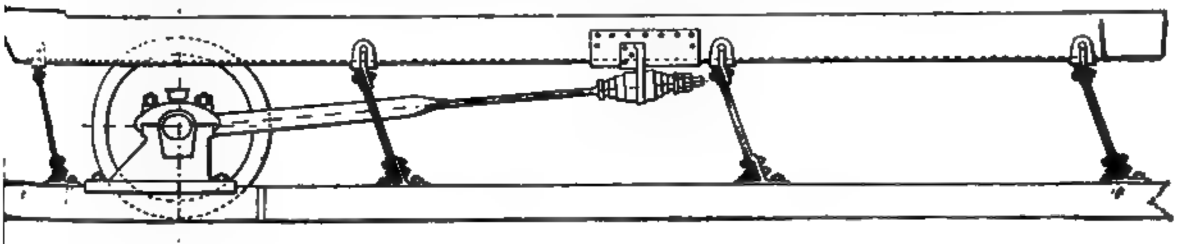


Fig. 85. Elevation of Swinging Conveyor.

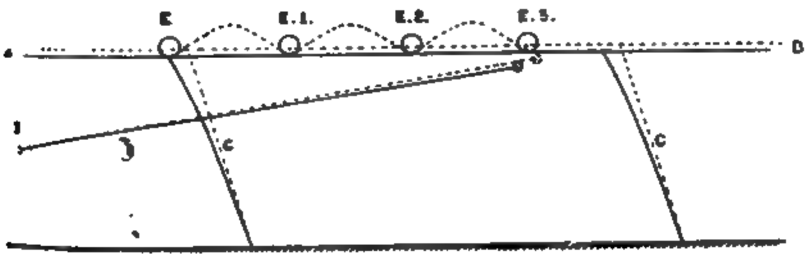


Fig. 86. Diagram showing Action of Swinging Conveyor.

Fig. 87. Trough of Swinging Conveyor.

cable trough conveyors. It is obvious that every kind of material which deteriorates through rough treatment should be conveyed on appliances of the former types.

The credit of the introduction of this appliance in its original form is due to Herr Eugen Kreiss, of Hamburg.

There are several varieties of the vibrating trough conveyor. In some, the trough makes a reciprocating motion by means of a crank and connecting rod, whilst the trough itself is supported on rollers (Thomson's patent) or portions of rollers; others are actuated by a cam, or by cranks with some kind of quick return motion.

The support of the trough in its reciprocating motion has been effected by links and by spring legs in an oblique position, the latter form being more generally used for two reasons.

Firstly, these spring legs are securely bolted at one end to the floor or other support, and at the other to the conveyor trough itself, and consequently require no lubrication.

Secondly, the combined action of the reciprocating motion of the trough and of the rocking of the spring legs causes the material to travel faster in the trough with a given stroke of the crank than with any other support.

The swinging conveyor is built on the above principle. The diagram in Fig. 86 illustrates its action. The diagram is greatly exaggerated, as the movements are too minute to show on a small scale diagram. The lines AB represent the bottom of the trough; CC are two of the spring legs. The lines in full show these legs at the extreme backward position of the crank D, and the dotted lines also show AB, CC, in the forward position of the crank. Let E be the object to be conveyed. At the moment the trough moves forward and upward, E is thrown also forward and approximately at right angles to the slanting legs CC, and before E has time to complete its short parabolic course, the trough has been moved by the crank into its original

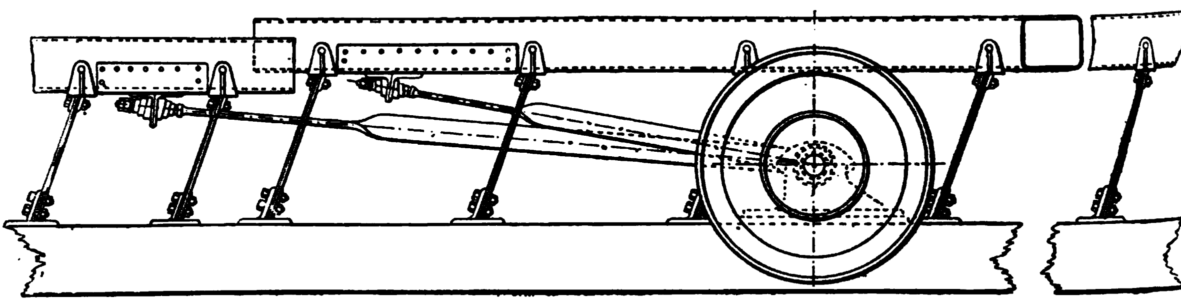


Fig. 88. Elevation of Balanced Swinging Conveyor.

position to receive it, when the same process repeats itself again and again, the progress of the object being indicated by E^1, E^2, and E^3. In reality the horizontal movement of the trough is only about 1 inch, and the vertical between the dotted and the full lines only $\frac{1}{8}$ inch. If the trough is full, the material moves, as it were, in a solid mass. There is neither friction between the particles of material nor between the trough and the product, as it is a hopping and not a sliding motion which propels the material.

Figs. 85 and 87 show one of these conveyors in elevation and in cross section. It is of the original type with a few improvements. Such a conveyor would be suitable for lengths of 50 feet and for widths up to 24 inches. It has been shown that the original conveyor could only be used in comparatively narrow limits; but this appliance has now been improved, and is well known, especially in colliery districts, as the "Zimmer Conveyor." It is used in lengths up to 500 feet, and in widths up to 6 feet 6 inches. The essential improvement which rendered it possible for this conveyor to be made in such lengths was the introduction of the balancing device, by means of which the conveyor is made in two halves, one being about 2 inches higher than the other, so that one half delivers into the other half. The two sections are manipulated by triple and multiple cranks which stand at an angle of about 180 degrees to each other. One half of the conveyor moves forward whilst the other moves backward, and at the same

time the material is moved from end to end and in the same direction, as all the spring legs are of the same inclination. A portion of such a balanced conveyor is shown in Figs. 88 and 88A.

Fig. 89 shows a similar arrangement of balanced conveyors, the two sections of which work at an angle to each other, one half balancing the other. Ordinary balanced conveyors are necessarily driven at or near the centre of their length. In cases where this is not convenient, they may be driven at one end as shown in Fig. 90. In this type the balancing of the conveyor is effected by means of a powerful volute spring, which is compressed and released by one of the cranks and connecting rods, instead of being coupled to one half of the conveyor.

This acts as an accumulator, receiving and storing the surplus energy of the conveyor at its backward movements, and giving it up again as soon as the crank has passed the dead centre, where it is utilised to pull the conveyor back against the springs.

The swinging conveyor can be used to work partly in one direction and partly in another direction, by simply reversing the incline of the spring legs, and by joining the troughs at the junction by a flexible coupling.

The load can be fed into or withdrawn from any of these conveyors at any number

Fig. 88A. Cross Section of Balanced Swinging Conveyor.

of points without cessation of work. The material travels at the rate of 40 to 70 feet per minute when the conveyor is driven at 300 to 370 revolutions per minute, but the best speed is 300 to 350 revolutions.

The coupling between the trough and the connecting rod is not rigid, but two very strong volute springs are placed on either side of the attachment. This is for the purpose of allowing the trough itself to exceed the stroke of the crank by a fraction of an inch on either side, and as the radius of the crank is in most cases less than ½ inch, the total travel of the trough with each revolution of the crank is but little more than 1 inch.

The work of conveyors on this principle is not limited to a horizontal direction. Such conveyors can equally well be used for conveying material up and down inclines. They may be worked in a standing or a hanging position, the conveyor in the latter case being suspended by its spring legs from the structure above.

The success of the swinging conveyor is largely due to its simplicity and to the small driving power required, especially when it is fitted with the balanced drive, as in such a case half the spring legs are always in tension while the other half are relaxed, so that the power which has been stored in half the legs is utilised for tightening the other half immediately the crank has passed its dead centre.

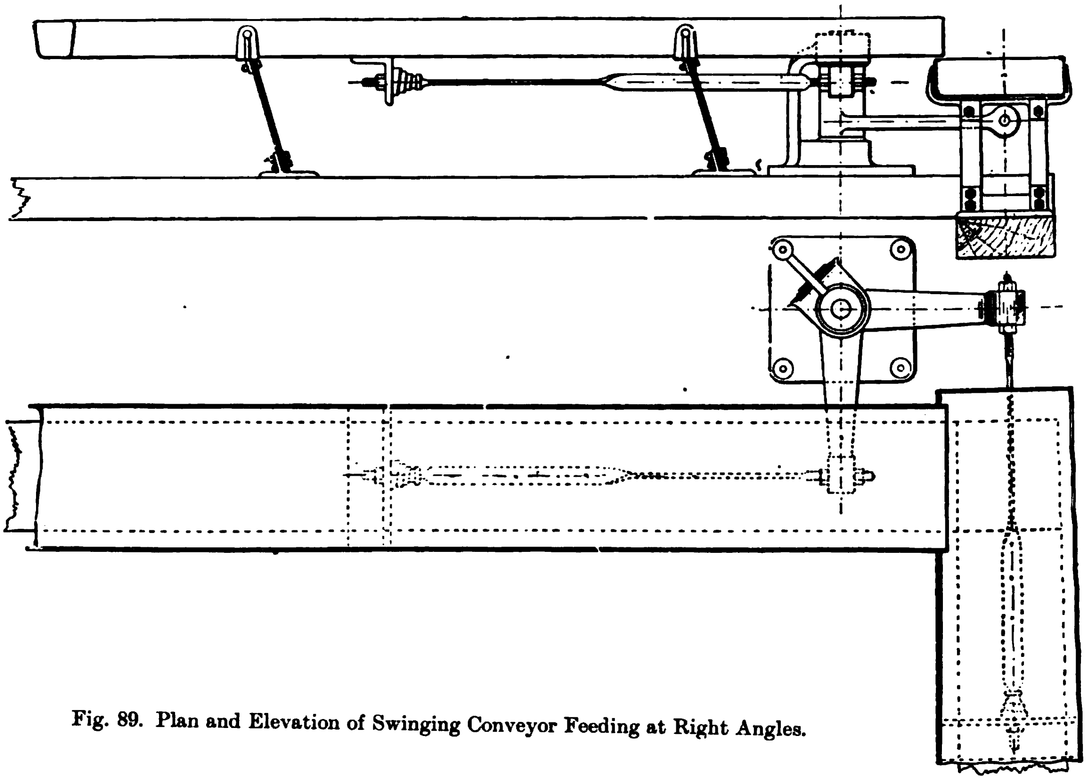


Fig. 89. Plan and Elevation of Swinging Conveyor Feeding at Right Angles.

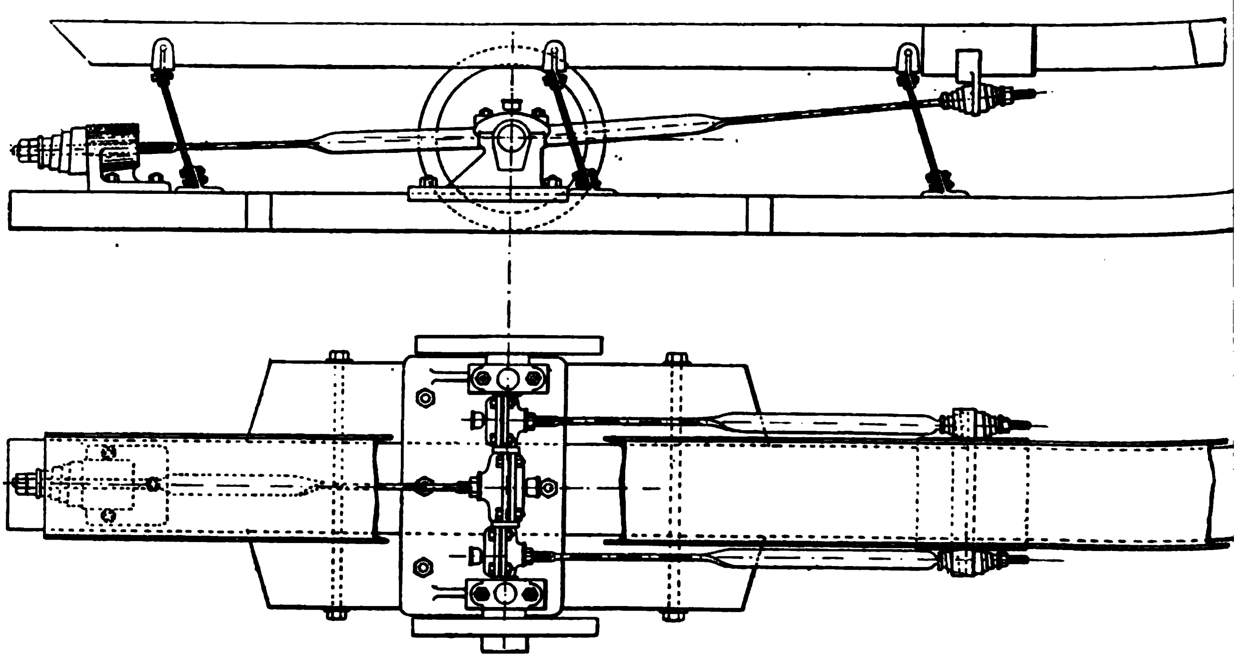


Fig. 90. Swinging Conveyor Balanced by Terminal Volute Spring.

The following table gives the capacity of this conveyor in tons of coal per hour for different sized troughs :—

CAPACITY OF SWINGING CONVEYOR FOR COAL.

	Width of Trough in Inches.								
	12	14	16	20	24	36	48	60	72
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Trough 4 inches deep	6–7	7–8	8–9	10–12	13–15	...	...	...	...
„ 6 „	9–10	12–13	13–15	16–18	18–20	30–32	35–40	45–50	50–60
„ 8 „	...	...	...	...	25–30	35–40	50–60	60–70	70–80

The capacities given in the table are for conveyors in a horizontal position. An incline of only 5 per cent. downwards will increase the capacity of the conveyor on

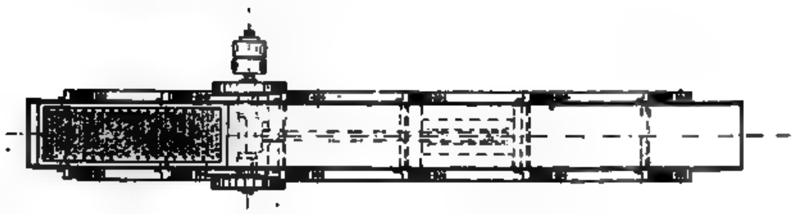


Fig. 91. Swinging Conveyor as used for Draining Purposes in connection with Coal-washing Plant.

some materials up to 10 per cent., while an incline upwards will reduce the capacity accordingly.

The power required to drive these conveyors may be judged from the following example. A swinging conveyor 100 feet long, conveying a load of 50 tons per hour, will require 8·75 HP.

The advantages of swinging conveyors are that they will convey any kind of

Fig. 92. Zimmer Swinging Conveyor as used for Picking Purposes.

material in large or small pieces, and cause next to no breakage to even the most friable material on account of their gentle action. By the use of ordinary slides in the bottom of the trough the material can be withdrawn at any number of points. There are but few parts, and fewer still to get out of order, whilst a special feature is the absence of a multiplicity of bearings and travelling gear.

This conveyor is used for a variety of purposes, a few of which are herewith illustrated and described.

For Draining Purposes.—Fig. 91 shows the swinging conveyor in connection with a coal-washing plant. The head-piece of the conveyor being fitted with a perforated plate, allows the water to at once escape, whilst the coal is conveyed to the further end. The conveyor has a slight upward incline. Thus should any water remain with the coal, it will tend to run back towards the feed end where it can escape through the perforations.

As a Picking Table.—The patent swinging conveyor can be used as a picking table, as the oscillating motion of the trough does not inconvenience the pickers after the first few minutes, and it has this advantage, that the coal is always uniformly spread

Fig. 93. Swinging Conveyor for Drying Purposes.

out over the whole surface. Hence picking is much easier work on this kind of conveyor than on the ordinary travelling band, where the coal remains in heaps just as it has been deposited on the band, and has therefore to be spread for examination by the pickers.

Fig. 92 shows two Zimmer swinging conveyors at work, which are used for picking purposes, at the Amelia Pit of the Cramlington Coal Co. Ltd.

A Drying Conveyor.—The peculiar and uniform floating movement of the material on the swinging conveyor renders this appliance particularly suitable as a cooling or drying apparatus. The material during the course of the journey on the conveyor can be either heated or cooled by the injection of hot or cold air into a chamber beneath the trough. Such a mode of conveying and cooling or drying the material, as designed by Commichau, is shown in Fig. 93. The floor of the conveyor trough on which the material travels is in this case formed of a series of plates overlapping each other like roof slates. A narrow space is left between each two for the air to escape, so that the material comes constantly in contact with the air. The current is created by a fan connected with the swinging trough by means of a flexible joint, which is best made in the shape of a leather, indiarubber, or moleskin sleeve.

For Conveying Sugar.—Moist sugar, which is a most difficult material to handle mechanically, can be satisfactorily conveyed by the swinging conveyor.

Fig. 94 illustrates a complete installation, both in longitudinal and cross section, of a sugar refinery, in which the conveying of the sugar from one machine to another,

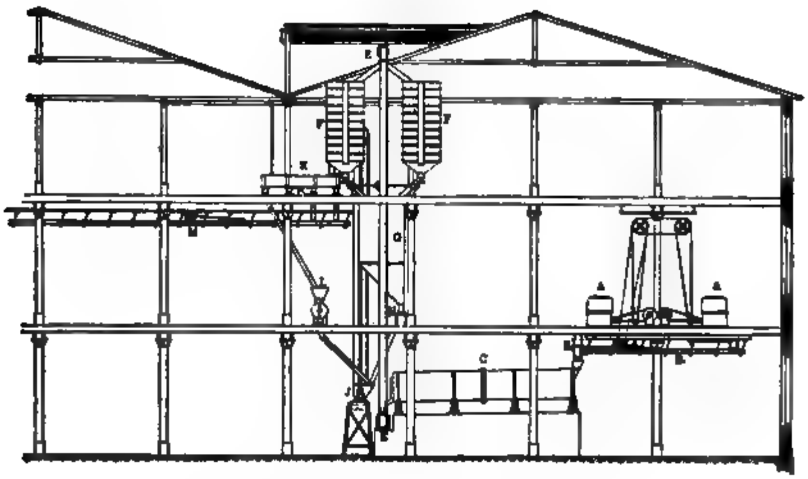


Fig. 94. Mechanical Plant for the Handling of Sugar.

and eventually to the store, is entirely automatic, being effected by swinging conveyors and elevators.

The sugar which leaves the sixteen hydro-extractors A in a semi-dry condition is deposited into the three conveyors B, which convey it to four granulating machines C. The conveyors B are suspended from the ceiling by their spring legs, and there are four independent outlets so as to convey the sugar in the right proportion to any of the granulating machines. On leaving these granulating machines the sugar is taken by

conveyor D and elevator E to the cooling apparatus F, from which it passes over bin G, conveyor H, and elevator J to the sifting machine K. Here it is separated into different sizes and carried by conveyor M to the warehouse. Conveyor M has several divisions so as to convey sugar of a different size in each division. The pieces which are too large and are rejected by the sieves K are broken up in a small mill L, and re-elevated to the sieve.

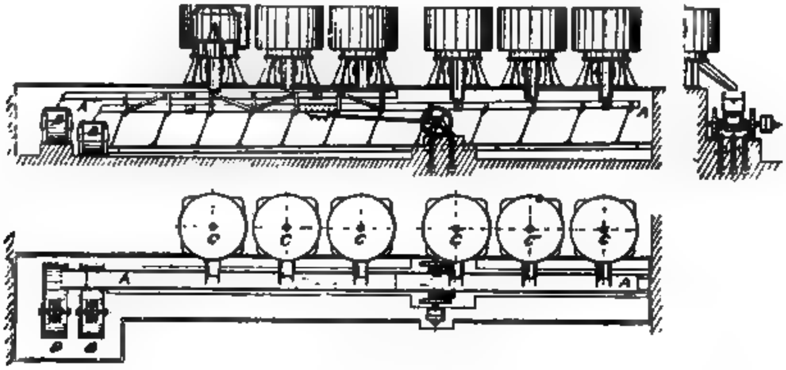


Fig. 95. Swinging Conveyor in connection with Hydro-extractors.

Another installation of similar design, in which one conveyor is used to convey sugar from six hydro-extractors, is illustrated in Fig. 95. The conveyor, with six extractors, is marked AA, whilst the two elevators into which the conveyors feed are marked BB, only the elevator wells being shown in the illustration. In this case the swinging conveyor has been designed with a second trough, mounted over and above the first trough at its delivery end, so that the sugar from the three first hydro-extractors

Fig. 96. Swinging Conveyor as Classifier for Coal.

CCC can pass beneath the second trough, into which the sugar from the other three hydro-extractors is passed. It will be seen from the illustration that the conveyor has a slight fall. This is an advantage in dealing with sticky materials.

As a Coal Classifier.—This conveyor is extensively used in collieries, where it is employed not only for conveying but also very largely for classifying or sorting coal into different sizes. When used as a sifter, the conveyor is fitted with an interchangeable

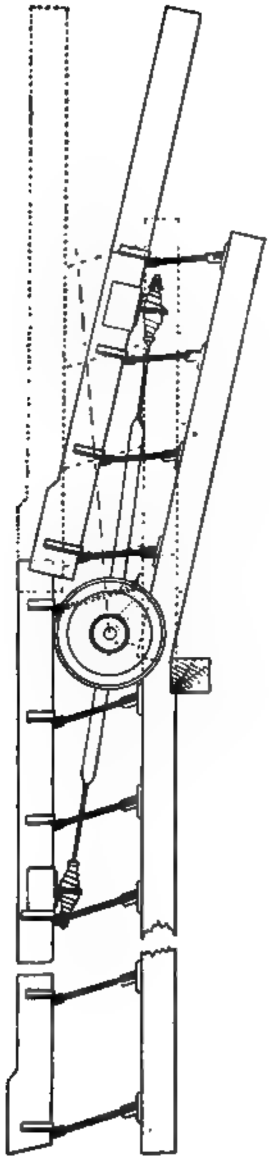


Fig. 97. Zimmer Swinging Conveyor as a Lowering Device.

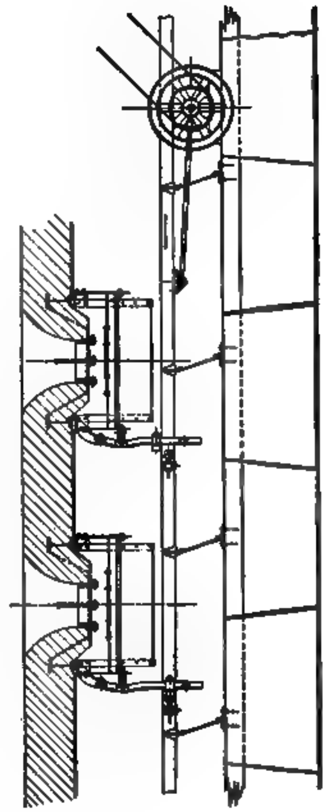


Fig. 98. Weiss Feeding Appliance in connection with Swinging Conveyors.

sieve which divides the trough into an upper and lower compartment; the fine material which has been sifted out by this perforated plate is conveyed on the bottom of the conveyor until an outlet is reached. The sifting action is so sharp that a perforated plate of 6 or 8 feet in length is sufficient in most cases to effect the separation. The sieves for different sized coal required can therefore be made of such lengths as to coincide with the row of sidings on which the trucks to be loaded can stand (see Fig. 96). Such a plant is at work in a Belgian colliery, where the coal is divided into a great number of sizes, each truck receiving coal of a different size.

Swinging Conveyor as a Lowering Device.—The swinging conveyor can be used for lowering coal and other friable material from the level portion of the trough to the railway trucks.

Fig. 97 represents one of these conveyors applied to this purpose. The driving gear is placed in such a position that the centre of the driving spindle forms the pivot for the jib end, so that this can be turned up or down, and will not affect the working of the conveyor. The jib end is connected with a winch in such a way that the delivery end can be placed in any position necessary. There need be no drop whatever from the delivery end of the trough if sufficient attention be paid to the adjustment.

The conveyor trough can also be extended by a hinged shoot which vibrates with the trough, but which has no spring leg supports as shown above, the extreme end simply being suspended from the structure above on chains, the length of which can be varied so as to give the shoot a greater or lesser incline.

The Weiss Feeding Appliance.—The feeding device illustrated in Fig. 98 is the invention of Mr Weiss, of Zürich, and has been designed for the purpose of automatically and uniformly feeding the patent swinging conveyor with coal from silos or stock heaps.

The illustration represents the apparatus in elevation and cross section, the latter view showing the swinging conveyor in a tunnel, with the feeding appliance over, in connection with the hoppered bottom of the coal store.

The feeding device consists principally of a table above which the coal enters. This table is set into an oscillating movement, and thus allows the coal to drop from its sides into a small hoppered trough, from which it finds its way on to the conveyor. The oscillating motion is imparted to the table by a lever connected to the conveyor. This lever can be thrown in and out of gear, and it is obvious that when thrown out and the table at rest, the flow of coal will cease.

The latest development of this type of conveyor is Zimmer's patent free swinging conveyor, in which the connecting rod is not attached to the trough at all, but to the spring legs at a point about a third or half way from the base, thus allowing the free ends of the legs to swing the trough backward and forward, whereby the stroke is amplified, the capacity increased, and the vibration to the structure reduced to a minimum. Such conveyors are most suitable for conveying large quantities, as the capacity is more than double that of ordinary swinging conveyors.

CHAPTER XI.

TIGHTENING GEARS FOR ELEVATORS AND CONVEYORS, AND SUMMARY OF DRIVING POWER, SPEED OF TRAVEL, AND WEAR AND TEAR OF ELEVATING AND CONVEYING MACHINERY.

THE same tightening gears can be used for a variety of elevators and conveyors. Those shown in Figs. 1 and 2, page 8, are suitable for small conveyors, as the adjustment will not allow of great latitude.

The tightening gear shown in Fig. 99 is more suitable for tightening a conveyor band, although it allows of only a short movement. Tightening gears of the same construction can be made of much greater lengths. The adjustment screw is fitted with a nut, so that the position, once adjusted, can be firmly secured. The screw can also be fitted with a hand wheel.

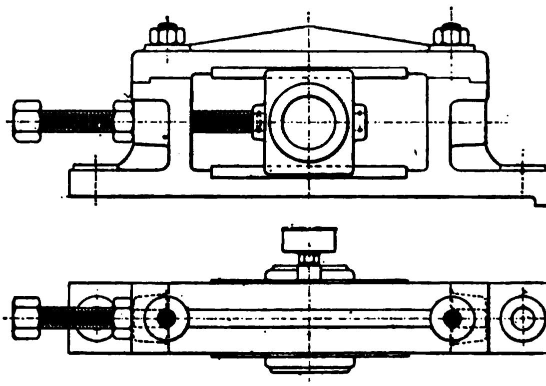


Fig. 99. Tightening Gear for Conveyors.

Fig. 100 shows a similar tightening gear, manipulated by screws and hand wheel. This gear is particularly suitable for long conveyors where a great deal of adjustment is required, as the position of the tightening gear can be altered on a base plate into a variety of positions.

Figs. 101 and 102 are driving gears suitable for the driving end of elevators or conveyors in cases where the respective machinery is driven by spur gear. It will be seen from the illustrations that the tightening gears consist of two bearings movable in a sliding frame, the two bearings being movable together in the correct position corresponding to the radii of the two spur gears, so that when the chain requires tightening both terminal wheel and countershaft can be adjusted at the same time. The foregoing types are the designs of Commichau.

Driving Power required for Different Types of Conveyors.—In order to afford an easy comparison between the driving power required by the conveyors described

in the preceding pages, the table given below has been compiled. It gives the capacity per hour of different conveyors for loads of 50 tons and lengths of 100 feet.

	Horse-power.
Band conveyor for grain	4·8
„ „ minerals	5·0
Swinging conveyor (balanced)	7·75
„ „ (unbalanced)	8·75
Push-plate conveyor	12·8
Worm conveyor	25·0

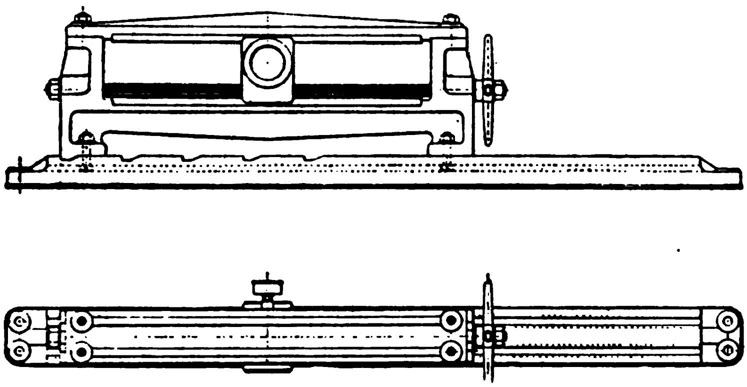


Fig. 100. Type of Tightening Gear for Long Adjustments.

Some difficulty has been experienced in obtaining reliable data concerning power consumed by conveyors, but the figures given above may be relied on for practical purposes.

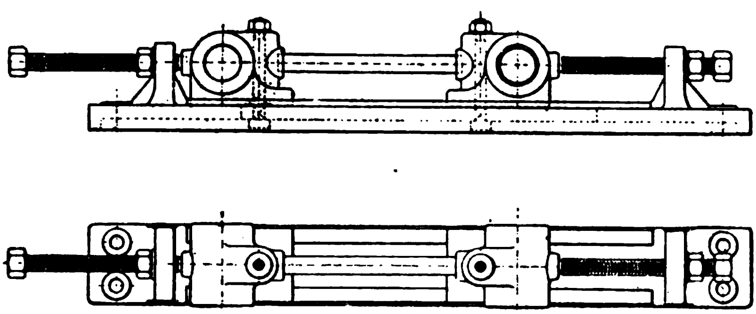


Fig. 101. Type of Tightening Gear for Conveyors with Spur Gears.

COMPARATIVE RATES OF TRAVEL OF THE DIFFERENT TYPES OF CONVEYORS.*

						Average Speed.
Band conveyor (for grain)	between	250	and	600	feet per minute	425
„ „ (for heavy material)	„	150	„	750	„ „	450
Push-plate conveyor	„	50	„	180	„ „	115
Trough cable conveyor	„	100	„	120	„ „	110
Travelling trough conveyor	„	60	„	120	„ „	90
Patent swinging conveyor	„	40	„	70	„ „	55
Worm conveyor	„	40	„	60	„ „	50

* The above speeds are taken from conveyors in actual work, but the author can see no reason why push-plate, trough cable, and travelling trough conveyors should not be run at 60 to 180 feet per minute.

Wear and Tear of Elevating and Conveying Machinery.—It may be of interest to compare the upkeep of elevating and conveying plant of different types given in the foregoing table.

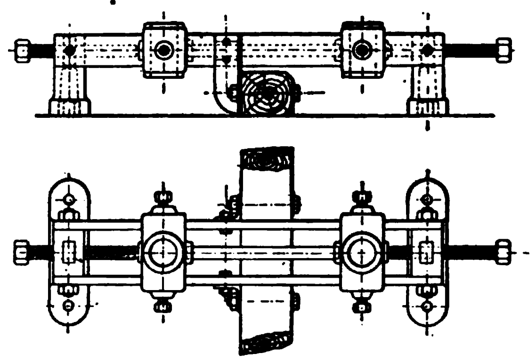


Fig. 102. Another Type of Tightening Gear for Conveyors.

With the exception of the last item, the following table has been compiled by the late Mr W. R. Chester, of Nottingham, who, as engineer to the Nottingham Gas-works, tabulated this valuable information from plants under his personal supervision.

The last item in the table was furnished by Mr Weiss, the engineer of the Zürich Gas-works, where several swinging conveyors have been at work since 1898.

Apparatus.	First Cost. Total.	First Cost. Per Foot Run.	Tons of Material Transported.	Distance of Traverse.	Costs for Repairs and Renewals. Total.	Costs for Repairs and Renewals. Per Ton.	Costs for Repairs and Renewals. Per Ton for 100 Feet of Traverse.	Description of Material Conveyed.
	£	£ s. d		Feet.	£ s. d.	d.	d.	
Elevator - -	1,554	4 4 0	335,237	74	86 1 6	0·061	0·082	Coal.
,, - -	819	6 6 0	178,541	58 & 72	679 6 8	0·913	1·405	Partially hot coke.
,, - -	428	5 7 0	37,685	40	7 4 0	0·046	0·115	Oxide of iron and lime.
Push-plate conveyor	296	2 9 4	149,350	30	70 6 0	0·113	0·377	Coal.
,, ,,	1,486	5 3 11	29,769	{ 90 90 106 }	110 11 3	0·891	0·938	Hot coke.
Plate-belt conveyor	2,026	3 12 6	149,350	{ 125 125 125 125 60 }	2,311 0 0	3·714	2·070	Hot coke.
Canvas band - -	443	4 10 0	say 10,000	98	40 0 0	say 1·00	say 1·00	Small coke and breeze.
Band conveyor -	296	2 9 4	149,350	30	70 6 0	0·113	0·377	Coal.
,, ,, -	172	1 11 3	2,180	110	42 1 1	4·63	4·21	Sulphate of ammo
Swinging conveyor -	1,767	1 0 6	250,000	{ 21 conveyors. Total length 1,722 feet }	15 0 0	0·114	0·0003	Coal.

CHAPTER XII.

THE GRAVITY OR TILTING BUCKET CONVEYORS.

Combined Elevators and Conveyors.—There are only two types which come under this heading:—

The gravity or tilting bucket conveyor, and the pneumatic conveyor.

The Gravity or Tilting Bucket Conveyor.—This conveyor consists of two endless chains or ropes held at fixed distances apart by suitable bars which are fitted with small rollers at each end. Every link, or sometimes every second link, carries a bucket, so that the whole is an endless and unbroken chain of buckets, which are not, however, fixed like elevator buckets, but are movable and suspended above their centre of gravity.

When this conveyor is at work the buckets will always be in an upright position, whether they are moving horizontally or vertically. Each bucket carries its load to the point at which its delivery is required, and here it is met by some adjustable device which generally tilts each bucket in turn, and thus empties the contents.

The gravity bucket conveyor enjoys great popularity, especially in America, and the details of some of the best forms have been most carefully designed. Where coal has to be conveyed to overhead bunkers in boiler-houses, this kind of conveyor certainly has great advantages. Instead of using a separate conveyor to bring the coal from the railway sidings and installing an elevator to raise it to the level of the bunkers, at which point a second conveyor must be used to distribute the coal from the elevator to the different compartments of the bunkers, one travelling bucket conveyor will perform these three operations, while sometimes the returning and therefore empty strand of buckets is used to convey the ashes away from under the boilers.

The driving gear is in some cases not unlike that of the ordinary chain-driven elevator, but more often it is independent of the conveyor, and actuates it by a series of pawls attached to a wheel, each of which pushes the conveyor forward, link by link. Or sometimes there is a wheel, with suitable projections, which are of the same pitch as the buckets, and which gear, as it were, into a portion of the continuous chain of buckets either on the inside or on the outside of the strand.

The devices for loading each of the buckets without spilling the material are of great importance in this type of conveyor. They are very numerous, and are fully detailed later.

Figs. 103 and 104 show sections of two distinct types of the travelling bucket conveyor, the "Hunt" and the "Bradley."

The speed of travel of these conveyors is slow, and the necessary capacity is obtained by installing buckets of a size corresponding to the load to be conveyed. The normal rate of travel is 40 feet per minute, but it can be either increased or decreased within limits of 25 and 50 feet according to circumstances. The power required is comparatively

Fig. 103. The Bradley Conveyor.

Fig. 104. The Hunt Conveyor.

small, and depends to a large extent on what proportion of the length is used for elevating.

A conveyor of this type offers the undoubted advantages of handling material in the gentlest possible manner, and of consuming but little power. One main drive is sufficient for a whole installation. The material can be fed to or withdrawn from the conveyor at any point. But it has this disadvantage, that if one portion of the installation breaks down, the whole is at a standstill; whereas, if different appliances are used for elevating and conveying, a portion of the whole can generally be at work. Moreover, there are a large number of journals to be lubricated and kept in repair. The former operation is, however, automatically effected in some of the best conveyors.

The Hunt Conveyor.—The Hunt conveyor, which was probably the first successful one of this class, consists of a double link chain carrying a series of pivoted buckets suspended in such a manner that they maintain their vertical position, and are free to revolve on their axes at all points of their path except at the place in which they discharge, this operation being effected in a very simple and efficient manner by means of a cam action, whilst the buckets on being released right themselves and are ready to be refilled. The buckets pass through the cycle of their motions continuously filling and emptying at any given points, the discharging being so simply performed that by merely moving a lever the contact can be made or broken. The action is complete, the buckets being so tipped that nothing is allowed to remain in them after they pass the discharging point.

The chain is centrally supported and centrally driven, the wheels being placed between the links of the chain, while each alternate pair of wheels has an axle traversing the space between the two chains and correctly maintaining the distance between them, thus preventing distortion or alteration of the track gauge.

The buckets are suspended on pivots projecting from the inner side of the chain, and are so arranged that by withdrawing two pins each bucket can be removed from the conveyor without disturbing any other part.

The wheels are so made that each will carry enough lubricant to provide for a certain period of running without attention.

The track consists of a special section of headed rail, joined together in convenient lengths by double fish plates, securely bolted through the rails, and resting upon cast-iron standards, to which the rails are bolted by means of hook bolts, obviating all drilling of holes, and consequent reduction of the rail section.

The curves which change the direction of the movement of the buckets are, as far as possible, formed as free wheels. Each pair of wheels is bored, turned, and keyed on a steel spindle, running in bushed and automatically lubricated bearings. The wheels of the conveyor chain are thus at rest and move round with the curve wheel rims, thus minimising friction and preventing wear at these important points where the stress is greatest on the conveyor chain.

By this improved and combined provision for movement a great reduction has been effected in the driving power. The tightening curve is provided with slides and tension screws, which enable it to be moved so as to take up any slack in the chain which may be formed.

The automatic continuous filler consists of a short endless chain, carrying seven funnels and supported in a frame, the funnels successively covering the buckets of the conveyor, and as the filler chain is driven by contact with the conveyor chain, the spacing and filling is accurate and uniform. These funnels and chains move round an

Fig. 105. General Arrangement of Pan and Bucket Conveyor.

oval track formed in the filler frame, and are supported on wheels similar to those of the conveyor chain.

The driving gear is so designed as to propel the chain by means of pawls which successively engage with the cross studs of the chain (see Fig. 104) and give a central thrusting action. The two parts of the chain are driven equally and simultaneously.

Fig. 106. Position of the Pans and Buckets on the Upper Strand.

The Pan and Bucket Conveyor.—This conveyor is built by the Steel Cable Engineering Co. of Boston, U.S.A. In its perfected form it differs considerably from the original type, and includes a great number of improvements. It consists of a continuous trough built in sections and supported on axles and guide wheels running

Fig. 107. Position of Pans and Buckets on the Lower Strand.

on suitable rails. There is one axle to each section, and in each section of the trough a bucket is pivoted to the sides.

The axles are securely clamped to two endless steel cables instead of the chains which are frequently used on conveyors of a similar type. This conveyor can be loaded when ascending, in which case the material is conveyed from a spout, and the process is similar to the feeding of an elevator. Material can also be fed at any point on the lower horizontal strand, as the conveyor itself consists of an endless trough similar to an

endless trough conveyor. Thus when the conveyor runs horizontally, the endless trough receives the feed; but as soon as the ascent begins, each short section of trough empties itself into its respective bucket, so that when ascending the buckets are separately suspended from their pivots and the trough runs empty at the side.

The discharging of the buckets is performed by a tipping device which can be so set that the contents of the buckets can be discharged at any desired point. The upper surface of the tipping gear is so corrugated as to give the bucket a jarring motion, which shakes out any material that might otherwise adhere to the sides.

Fig. 105 gives a general outline of such a conveyor when receiving coal. The illustration shows on the left the railway truck which brings the coal and takes away

Fig. 106. Feeding Device for Pan and Bucket Conveyor.

the ashes. The truck is preferably self-unloading, and beneath it is shown a coal-breaker which reduces the coal to a more uniform size, and then delivers it in a regular feed to the ascending buckets of the conveyor and deposits it in the bunkers over the boilers.

The return portion of the conveyor when not in use for carrying coal can be used for removing the ashes. One of the boilers is shown in the illustration, from which it will be seen that the ashes are collected in hoppers which deliver in a similar manner to those beneath the coal-breaker, so that the ashes can be deposited into the conveyor whenever it is available for this purpose. They are then discharged just above the hopper from which the contents can be loaded into trucks at intervals. The illustration clearly shows the driving gear, the feeding and tipping devices, as well as the arrangements for keeping the chain taut.

The buckets of this conveyor are made of stamped steel. In the continuous pan section there are no joints whatever, as the sections can be bent out of one piece, and overlap each other to prevent leakage. They depend for their alignment with each other upon the wheels and axles upon which they are supported, and for their pitch upon the cables which connect them.

Each bucket is provided with a small roller which is used for its discharge. It is claimed for this conveyor that it is very easy to replace any portion should this be necessary, as the clamps by which the axles are attached to the cables are fully accessible along the entire upper strand. This will be seen from Fig. 106, which shows a portion of this pan and bucket conveyor in position on the upper strand.

Fig. 109. Feeding Device for Sticky Material with Pan and Bucket Conveyor.

Fig. 107 shows a portion of the same conveyor on the lower strand.

Fig. 108 represents the ordinary feeding device, from which it will be observed that spilling is impossible, as the conveyor forms a continuous trough, so that what one bucket misses must drop into the next one.

Fig. 109 illustrates a similar feeding device used with sticky material, which gives the delivery spout a slight shaking to prevent clogging.

In Fig. 110 the conveyor is erected in a tunnel with two baffle plates over, so that the coal or any other material to be conveyed can be thrown into the conveyor from the floor on either side.

The Bar-link Conveyor.—This conveyor, which is built by the Steel Cable Engineering Co., is another form of the tilting bucket conveyor, and has the buckets so arranged that they can be loaded at any point on the lower strand without the necessity of employing a loading device. Any spilling between the buckets is prevented by placing an additional axle and guide pulleys between each pair of buckets, the extra spindle being in such a position that when the buckets are on the lower strand it covers the space between each pair. The buckets are held in position while loading by a roller attached to each one. This roller travels on a separate guide rail as shown in the illustration. These rollers will also keep the bucket in position upon the upper strand, and during the process of discharging. The axles are connected by steel bar links, and the guide wheels are fitted with self-lubricating attachments. The illustration

Fig. 110. Pan and Bucket Conveyor receiving Feed from Floor on either Side.

shows all the corner guides as well as the loading and discharging devices, and also the driving gear.

Swinging Bucket Conveyor.—The swinging bucket conveyor is similar to that previously described, with this difference, however, that the buckets are suspended at one end instead of in the middle. This arrangement is intended to facilitate their discharge. During conveying on the lower strand the buckets are held in a horizontal position, and so readily receive the feed. The illustration shows the feeding device, the delivery and the attachment for turning the buckets over into their original position, as well as the automatic tightening arrangement.

Continuous Bucket Conveyor.—A type of conveyor which empties itself not by tilting the bucket, but by opening it, is the continuous bucket conveyor built by the Steel Cable Engineering Co. of Boston. The buckets in this case are divided longitudinally for the purpose. The conveyor itself is used in a similar manner to other travelling or tilting bucket conveyors. It will therefore suffice to show the bucket in its delivering position only. This is represented in Fig. 113.

Fig. 111. General Arrangement of Bar-link Conveyor.

Fig. 112. General Arrangement of Swinging Bucket Conveyor.

There is a lozenge-shaped frame made of round iron bars with which the buckets engage when approaching it. This opens the two halves, and allows them to close gently as the bucket passes off at the other end.

The Bousse Conveyor.—The latest development of the system is the Bousse gravity bucket conveyor, which was designed to overcome the drawback of other conveyors of the same type, namely, inability to work except in one plane, or at least with only a very slight deflection. It is claimed for the Bousse conveyor that

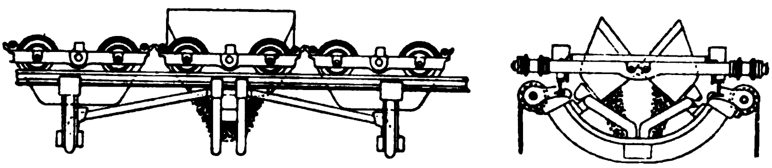


Fig. 113. Portion of Continuous Bucket Conveyor.

it will go round any incline backward and forward in both planes, and that it is therefore adaptable for installations where the ordinary travelling bucket conveyor would be useless. The conveyor consists of a number of miniature carriages, which are each fitted with two spindles and four wheels. The carriage resembles a minute contractor's truck (see Fig. 114); it is pivoted above its centre of gravity, round which pivot it can be tilted. The trucks are coupled together by a coupling bar, and these coupling bars allow not only of an upward and downward motion, but also of a side movement within

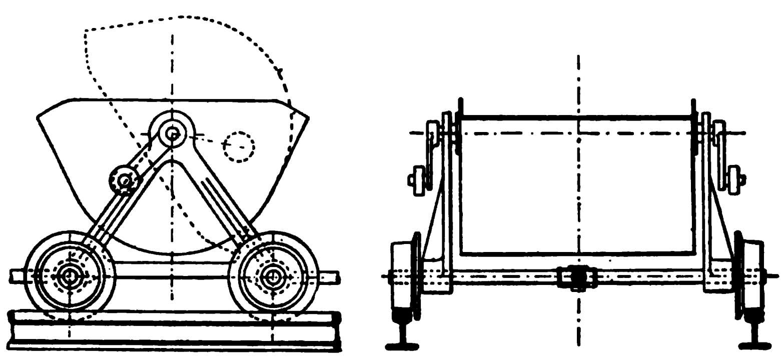


Fig. 114. Bousse Conveyor.

certain limits. It is supported on a pair of rails similar to other conveyors of this type. The axles are provided with sufficient lubricant to last for several months.

A simple feeding device has been designed for the purpose of filling the buckets; it consists of an outlet controlled by a valve which opens automatically every time a bucket presents itself beneath it, and as the buckets can be set further apart for elevators of small capacity, the opening of this slide can be set to suit any pitch of buckets. On the other hand, should a higher capacity subsequently be required in any installation, the buckets can be set closer together, and thus the filling machine is correspondingly altered to suit the pitch of the buckets. The emptying of the buckets takes place in a similar manner to those of the conveyors already described. This conveyor is reported

Fig. 115. Hunt Conveyor in connection with Chalk Handling Plant.

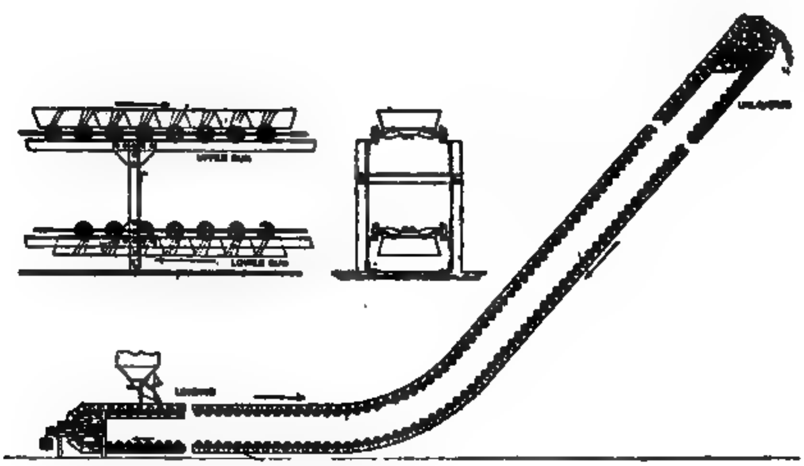


Fig. 116. Continuous Travelling Trough Conveyor with Partitions.

to be successfully at work in several boiler-house installations, as well as for coaling locomotive engines.

This conveyor is built in six sizes for gauges of 20, 24, 28, 32, 36, and 40 inches, with a capacity for each bucket of $\frac{1}{4}$ to $\frac{1}{2}$ cwt. of coal. The buckets are placed at a pitch of 20, 30, 40, and 50 inches, and it is claimed that a capacity of over 100 tons per

Fig. 117. Continuous Trough Conveyor with Partitions in a Vertical and Horizontal Position.

hour can be reached. It is said that the speed of this conveyor can be varied from 30 to 100 feet per minute. There seems, however, no apparent reason why this particular conveyor should run faster than any other swinging bucket conveyor, to which type it closely conforms.

This conveyor is built by the Humboldt Engineering Works Co., of Cologne.

There are many other designs of conveyors of the tilting bucket type, which do not, however, present features sufficiently distinctive to entitle them to separate descriptions.

Hunt Conveyor as used in connection with a Chalk Handling Plant.—This installation is illustrated in Fig. 115, and is used for conveying broken chalk for cement manufacture. The material is delivered alongside in barge loads, and is discharged by means of two steam grabs and cranes into a double receiving hopper on the jetty. These hoppers deliver into two breakers which reduce the chalk to a suitable size for handling in the cement works, and deliver it into a stock heap, in the first instance by means of a Hunt travelling bucket conveyor. The capacity of this plant is 60 tons of broken chalk per hour.

The installation was erected by Messrs Babcock & Wilcox for Messrs Caseborne & Co., Haverton Hill-on-Tees.

Continuous Travelling Trough Conveyor with Partitions.—This conveyor has much in common with the continuous trough conveyor, but as it both elevates and conveys the material, it has been included in this chapter. It can be used not only for conveying on a level, but will also admit of conveying up inclines, and will even work in a vertical position. A conveyor of this type is built by the Steel Cable Engineering Co., under the name of the rigid partition conveyor. It is driven, like most of their conveyors, by steel cable, and each section of the trough has its own guide wheels, which run on suitable rails, as shown in Fig. 116; discharging point H is also clearly visible.

Each section has a partition across its lower portion which forms a kind of bucket. The illustration shows the feeding of the conveyor at the level portion, the material being fed on in the same way as it is on the pan and bucket conveyor. It is used for minerals, coal, &c., and is also employed to handle coke which has been quenched but is still hot.

Fig. 117 shows a portion of the same kind of conveyor in a horizontal and vertical position. The feeding device and delivery shoot are clearly seen, as well as the automatic tightening gear for keeping the steel cable taut.

Unlike Fig. 116, the discharge of this kind of elevator and conveyor combined takes place on the lower strand. A trough, therefore, must be provided for the horizontal portion of the lower strand. This trough is fitted with doors or slides, so that delivery can be given at any desired point. In the case illustrated, the delivery is given by a horizontal door held in position by a chain. This can be closed, and some other door opened elsewhere. The partitions in the buckets act like the scraper plates of a push-plate conveyor in this trough.

CHAPTER XIII.

PNEUMATIC ELEVATORS AND CONVEYORS.

THE second appliance which combines elevating and conveying is the pneumatic elevator and conveyor.

About the year 1863 experiments were made with a view to elevating grain by means of air currents, and since then many patents have been taken out to solve this question in different ways.

Among the earliest and most important patents were those of Merrill of Brooklyn in 1873; of L. C. Renard and C. M. De La Haye of Paris, taken out in America in 1879; of Jaacks & Behrns of Lubeck, taken out in Germany in 1880; of Lyman Smith, taken out in America in 1882 and 1883; of Frederick W. Wiesebrock of New York, taken out in the United States in 1884; of the Rev. George M. Capell of Stony Stratford, Northampton, taken out in England in 1884; of Oscar Bothner of Leipzig, Germany, taken out in 1896. The first practical application of pneumatic power to the conveying of grain was in 1887, when the Cyclone grain transfer barge was constructed at Cleveland by Lyman Smith, and used for transhipping grain from lake vessels to canal boats.

An obvious advantage of such a system above ordinary elevators and conveyors is this, that in unloading ships the suction pipe can be readily conducted within the hold so as to reach every corner and confined space therein; hence such appliances save a large amount of manual labour in trimming grain which would be necessary with any other grain unloading appliance.

The only valid objection to pneumatic elevators is the large initial cost of their installation, and the large expenditure for fuel necessary to produce the air current. In other words, the driving power required to manipulate such plants is heavy. Pneumatic elevators and conveyors are therefore only suitable for large installations where this drawback is of minor importance.

As a matter of fact, the building of larger ships, the need for speedy discharge, and the desire to be independent as far as possible of manual labour, have in the past few years been the means of introducing pneumatic elevators to a considerable extent, notwithstanding their heavy initial cost.

There are practically three systems for elevating and transmitting grain by pneumatic means which might be termed—

1. *The Blast System.*
2. *The Suction System.*
3. *The Combined Suction and Blast System.*

The Blast System.—To give a practical illustration of the blast system, assume that it is required to load a ship from a lighter lying alongside. A barge called a machinery barge is fitted with a steam boiler, a set of air-compressing engines, and a quantity of flexible piping long enough to reach from any part of the lighter to the furthest corner of the ship to be loaded. To the inlet end of this piping, where the grain enters,

termed the nozzle, a small pipe is inserted. This pipe is in communication with the air compressor at the other end. A valve is fitted to it for admitting compressed air to the nozzle or shutting it off.

When a lighter comes alongside to be discharged, a flexible pipe with its grain inlet nozzle is pushed into the grain, while the other end is led over the hatchway of the ship to be loaded. Upon the air compressor in the machinery barge being set to work, and the valve opened in the compressed air supply pipe, the air naturally rushes up the pipe and escapes at the other end which terminates over the hatchway. If the hand be put over the nozzle where the compressed air enters, a strong suction will be felt, strong enough to draw in any granular material lying in close proximity to it.

Fig. 118. Application of Blast System of Elevating.

The action is similar to that of an injector, so that if the inlet nozzle be immersed in the grain to a depth of 12 to 18 inches, the induced atmospheric air following the compressed air will take the grain around it to the mouth of the inlet nozzle, carrying it up the pipe and delivering it into the hold of the vessel.

The following is a description of a blast grain elevator which has been brought out by the Atmospheric Grain Elevator Co. Ltd., under the Barclay and Walker patents.

This blast elevator raises from 10 to 50 tons of grain per hour. It was erected for experimental purposes at the works of the Compressed Air Power Co. Ltd., Birmingham, with whom the firm made arrangements for the use of their compressed air.

In the course of the experiment six pipes were used for elevating maize to a hopper

placed 40 feet above the ground. In order to register the quantity of maize moved by means of the blast elevator during one hour, the hopper discharged the maize into a "Chronos" automatic weighing machine, which indicated the exact quantity handled.

Of these six pipes, one was fitted up to raise 50 tons of material per hour to the bin 40 feet above the ground; two were made to elevate each 20 tons per hour to a hopper at the same elevation; two to carry each 15 tons of grain per hour to the same height; and one to convey the grain 40 feet in a horizontal line, and then to the hopper described as being 40 feet above the ground. The pipes acted as conduits, the grain being carried to its destination by the force of the air current, which, owing to the construction of the nozzle at the end of the pipe, sucked up the grain by reason of the blast entering the conduit pipe through the nozzle.

Fig. 118 shows the system adopted in practice by the Atmospheric Grain Co. for discharging grain from a vessel to a mill, warehouse, or to another vessel.

After a series of experiments the nozzle shown in Fig. 119 was adopted. It consists of an annular jet nozzle fitting at the entering end into the contracted throat J of the discharge trumpet J′, secured at its wide end to the first length of pipe of the grain conduits C. The inner nozzle I is screwed into a deep socket B and fitted with a lock nut *b* for regulating the opening of the annular jet of air issuing at J. The compressed air enters at D. The inlet end of the nozzle I is formed into a short trumpet H for leading in the grain. Of course the shape of the trumpet is altered if the nozzle is used horizontally or in an oblique position.

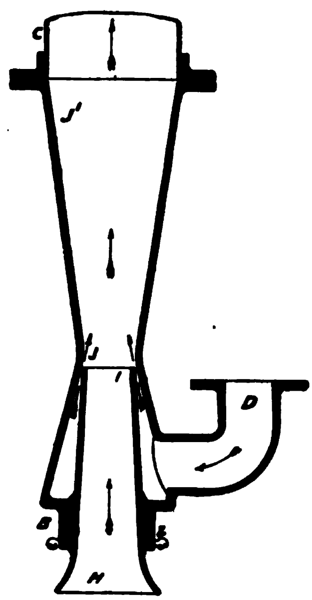


Fig. 119. Blast Nozzle of Pneumatic Elevator.

The Suction System.—This system in its earliest form undoubtedly owes its existence to F. E. Duckham, M.I.C.E. His principle will be readily understood from the following introductory description, bearing in mind what has already been said in regard to elevators working by compressed air. The plant of the Duckham system consists essentially of an air-tight tank or receiver, 8 to 10 feet in diameter, and about 10 to 20 feet high. This tank is hopper bottomed, and is erected, if floating, on a machinery barge at such a height that grain falling from the bottom of it, after discharging through an air lock would be delivered by gravity down a shoot to the grain-receiving vessel. This vacuum tank is placed in communication with the exhauster by means of a pipe.

Two or more ranges of pipes are attached to the vacuum tank. These pipes are flexible and are all of sufficient length to reach to the furthest corner of the vessel to be discharged. The end of the pipe where the grain enters is of special construction, to be described later on. It is generally called a nozzle, but necessarily it bears but little resemblance to the blast nozzle of the previous type. When the air pumps are started a partial vacuum is formed within the tank through a connecting pipe, and upon the nozzle end of the pipe being immersed in the grain to a depth of a few inches, the air is drawn in at the orifice of the nozzle, which carries it up the pipe to the vacuum tank.

The air, by sudden expansion from a 5 or 6 inch pipe into a large vacuum tank,

allows of the grain falling to the bottom and passing away by means of an air-lock valve, whilst the air is drawn down through a communicating pipe into the air pumps, and is led away by pipes from them.

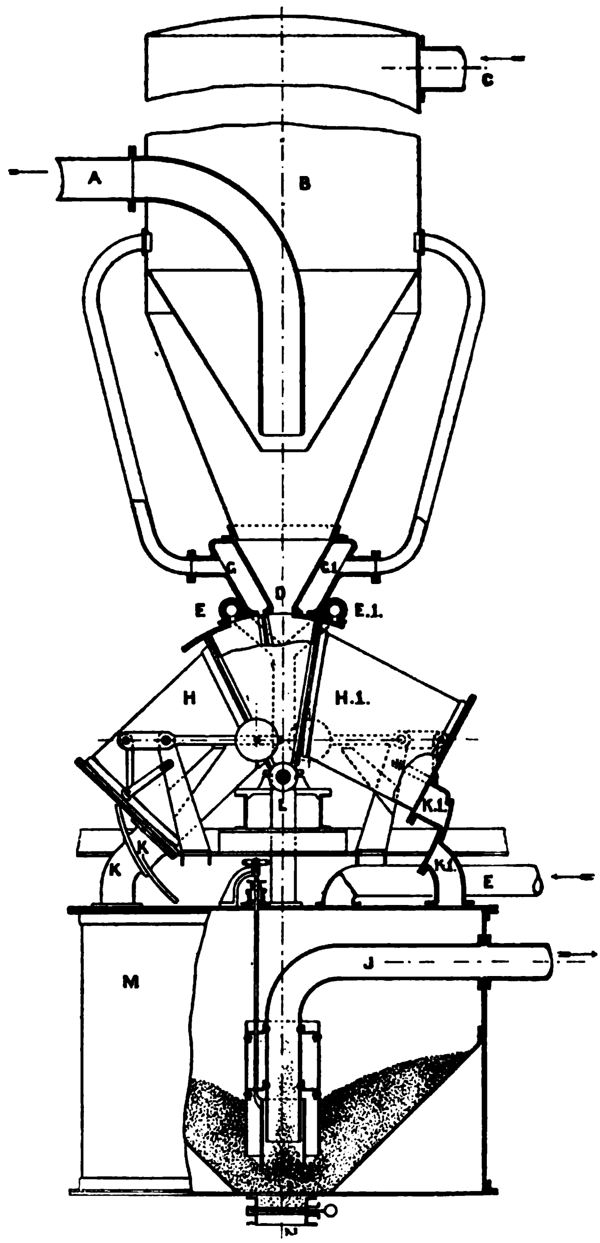


Fig. 120. Duckham's System of Pneumatic Elevating.

Combined Suction and Blast System. — The third method of transmitting grain by pneumatic means consists of a combination of the blast and suction system. The grain is sucked into a vacuum chamber as already mentioned, and from this tank is conveyed by means of a blast of compressed air through flexible pipes to any point desired. The tank may be divided into two sections, and fitted with a system of valves in such a manner that the two sections of the tank are alternately under the influence of blast or suction, or the grain may be discharged through an automatic or other valve from the vacuum tank into a second air-tight chamber which is put in communication with the compressed air chamber. This chamber is fitted with a grain discharging pipe, and the grain is forced through it by means of the compressed air as already described. There have been several practical applications of this latter system which appear to have given satisfaction.

Pneumatic blast elevators, and those combining suction and blast, are almost as widely used as the Duckham system of suction only.

Messrs Haviland & Farmer experimented with the blast system for some years, and tried hard to make it answer; but after much experimenting with the patents taken out by Walker and others between the years 1886 and 1890, it was found that such difficulties were inherent in the blast system of elevating as seriously to interfere with any chance of ultimate success, and it

was therefore abandoned. The velocity at which the grain entered the pipes was so great as to break the grain on reaching the bends in the pipes, and even where the berries were not actually broken, the husk was abrased, the action in the pipes being like that of a decorticator. A yet greater objection was the dust nuisance, as the grain and the accompanying air current escaped together from the delivery end of the pipes, and the air became laden with dust and fine sand to such an extent as to render it impossible for men to remain in the ship's hold for the purpose of trimming whilst the elevator was at work. This latter objection was not suspected by the patentees until a plant had been shipped and set to work in the Danube, when this proved an absolutely fatal objection to the use of the machine.

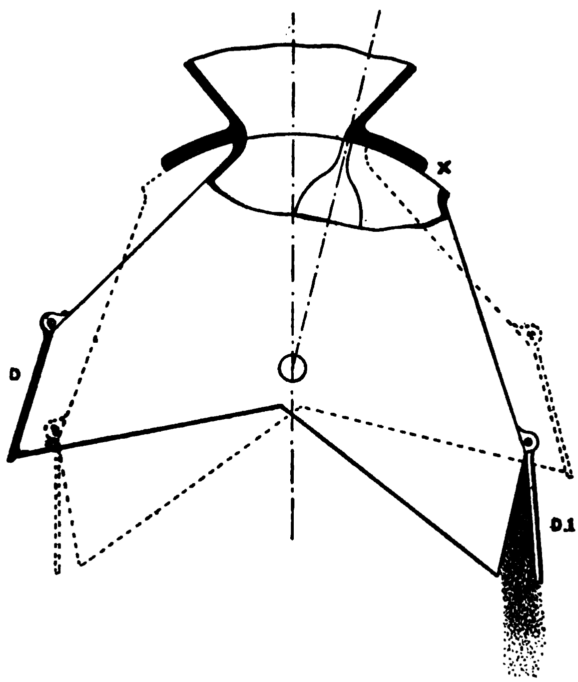


Fig. 121. Duckham's Pneumatic Air Trap.

The first modern suction elevator was erected by the Millwall Dock Co., under the Duckham Patents,* the first of which was taken out in the year 1890, and it is under these patents that all the existing pneumatic elevators at present in use in the United Kingdom were constructed. As the principle has already been outlined, it will now suffice to give the details of the different working parts of the invention. One of the chief items is the air trap through which the grain finds its exit from the tank without destroying the vacuum. This is effected by an ingenious arrangement illustrated, together with the tank, in Fig. 120.

The pipes A and C are connected to the tank B, the former leading to the grain

* Duckham's pneumatic elevator and conveyor are described in *Engineering*, 29th January 1897, 14th July 1893; also in *The Engineer*, 19th February 1897 and 8th April 1898. See Proceedings Inst. C.E., vol. cxxv.; see also Proceedings Inst. Naval Architects, 31st March 1898.

store or to the ship to be unloaded, and the latter to the exhauster. Beneath the tank B is the apparatus which withdraws the grain from the tank automatically without destroying the partial vacuum in the same. The apparatus consists of a receptacle divided into two compartments H and H^1, which oscillates on its axis L, so that alternately H and H^1 will receive the grain through the aperture D. The delivery spouts K and K^1 open and close with the same oscillating movement, so that when H^1 receives its load its exit K^1 is closed, and the inlet to H is closed whilst it discharges its load through K, which is open.

Fig. 120 shows not only the delivery of grain by suction, but also depicts discharge into granaries, &c., by air pressure. Thus the apparatus is illustrated in the form in which it has been used for the combined system of blast and suction. The tank M, which receives the grain alternately through the pipes K and K^1, is connected with pipe E, which forces the compressed air into the tank, and by the use of pipe J leads the grain and air away to its destination. The grain can also be withdrawn by N. This would only be the case were the apparatus in use under suction alone.

Fig. 122. Duckham's Suction Nozzle.

The ports G, G^1, and E, E^1, are for the purpose of establishing communication, and thus equalising the pressure between B and H, H^1, during the filling, or rather just before the filling operation takes place, and between M and H, H^1, just before the discharge begins.

In the later types of construction the air traps in use with the Duckham pneumatic elevators, especially those for suction only, have been much improved and simplified; their present construction is shown in Fig. 121.

The illustration shows the rocking air trap in the two positions, one in full and the other in dotted lines.

The exits from the two compartments D and D^1 are ordinary flap doors with indiarubber linings. They are held closed through the vacuum within during loading. When one compartment is full the whole apparatus swings over to the other position, and in so doing first shuts off the feed and with it the vacuum, and then opens a port X which communicates with the outer atmosphere, upon which the valve D^1 opens and allows the load to discharge, the aperture X being visible in the illustration. The partition between the two compartments is weighted, thus restraining the action of the apparatus until the compartment is full, when its own weight overbalances it. This appliance does excellent work, but as the air pressure in the oscillating pockets has not been withdrawn as in the apparatus previously mentioned, as soon as the empty pocket is brought into contact with the vacuum chamber, the air contained in the pocket expands so rapidly into the vacuum chamber that it causes a violent disturbance to the grain in the latter. The apparatus being automatic and self-acting requires a comparatively loose fit, and it is difficult therefore to make it absolutely airtight, and any leakage means waste of driving power. However, the extreme simplicity of this trap has much in its favour.

Fig. 122 shows the construction of the suction nozzle which explains itself, the action being similar to that of an injector. The suction pipe which connects this nozzle with the vacuum chamber is about 6 inches in diameter, and consists of plain wrought-iron piping for the straight lengths and flexible hose for the bends. The hose is armour-plated inside and covered with indiarubber with insertion to keep it air-tight.

For the sake of completeness the very simple delivery nozzle which is used in con-

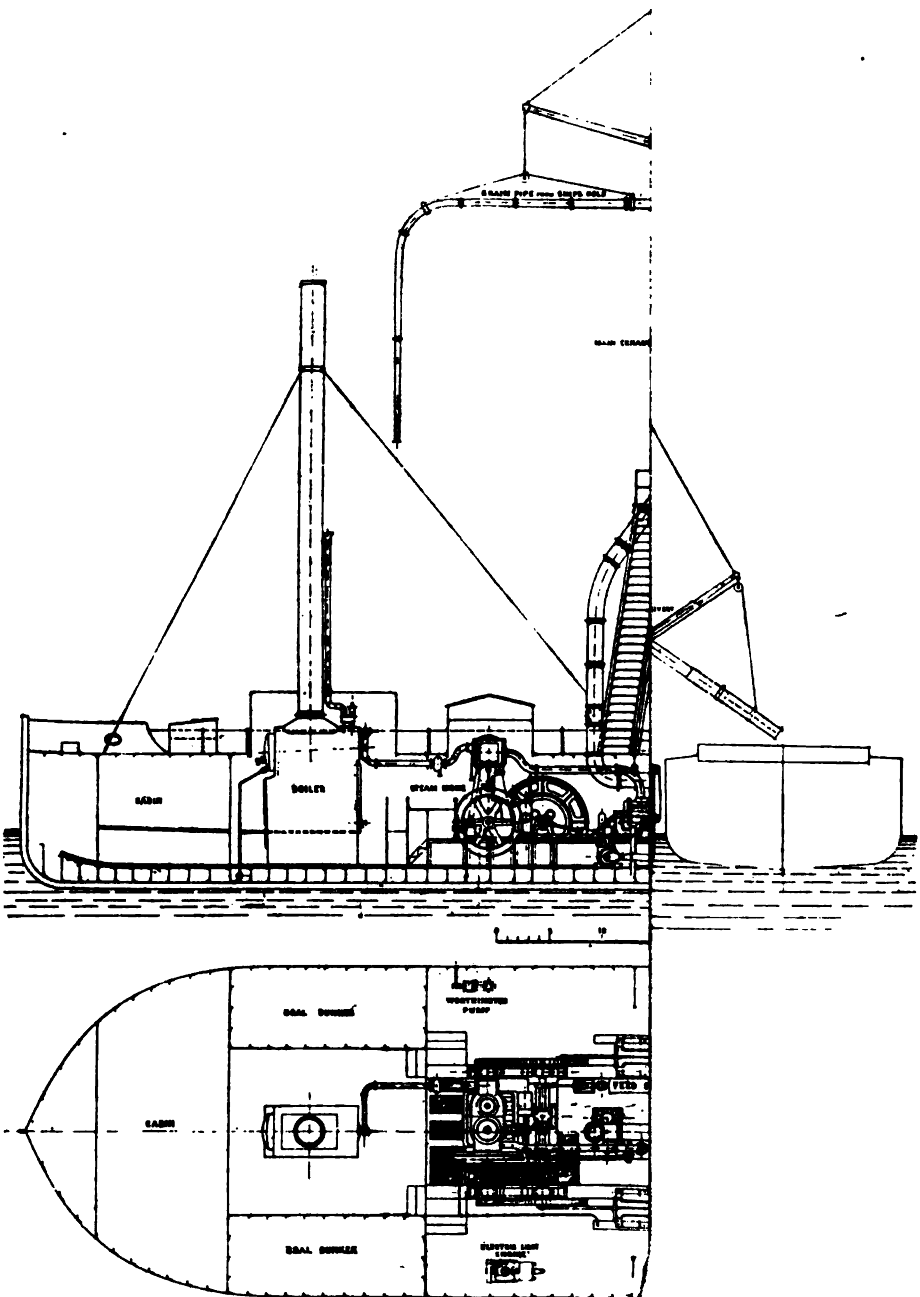


Fig. 124. Complete Installation D

[*To face page* 113.

nection with the combined system is here also given in Fig. 123. It consists of an iron pipe about two or three times the diameter of the supply pipe, and of a length of five to ten times the diameter of the latter.

The pipe which leads from tank M (Fig. 120) is connected to the delivery nozzle, and as soon as the air which carries the grain expands in the wider nozzle, the velocity of the grain is reduced, and it runs out of the pipe in a uniform stream. As mentioned above, this method of delivery has been successfully applied in several instances, the most important being the "Garryowen" at Limerick and the "Leitrim" at Sharpness.

The combined system can only be used effectively in cases where the grain has been sufficiently freed from dust before delivery, or in cases where the dust would be no objection.

A partial vacuum of about 10 inches of mercury is necessary to work this pneumatic conveyor. With this vacuum the grain travels in the pipe at the rate of 30 to 50 feet per second. One pipe has therefore a capacity of 30 to 40 tons of grain per hour. As one of the vacuum tanks is fed by at least two pipes, the capacity of a single installation through one air trap is 50 to 60 tons per hour.

The power consumed in driving such an installation is about 3 HP. per ton of grain to be conveyed per hour. This is rather high, in comparison with ordinary elevators; but as the whole appliance is so effective, and therefore requires a minimum of manual labour, it is undoubtedly most serviceable, particularly where very large quantities, such as cargoes of grain, have to be handled in the shortest possible space of time.

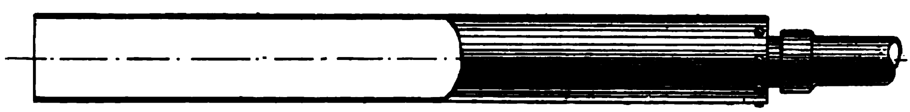


Fig. 123. Duckham's Delivery Nozzle.

Fig. 124 shows a complete installation of the Duckham elevator for discharging grain. It was built by G. Luther, of Brunswick, for the Hamburg and American line of steamers. It has a capacity of 150 tons of grain per hour, and has proved capable of very good work. A dust collector which is here employed is marked in the drawing. It is intended for the purification of the air before going to the exhausters.

Messrs Haviland & Farmer, after abandoning their original system, now work on the same system as that of Duckham. They claim to have made a number of improvements, and certainly some of their innovations are very noteworthy. They have paid special attention to the purification of the air between the vacuum chamber and the exhausters. In order to prevent wear and tear and consequent loss of driving power owing to the leakage of the air past the exhauster pistons, they have also introduced a new automatic air trap under the vacuum chambers which works on a different principle altogether to that of Duckham's. They are also using a suction pipe, but on somewhat different lines.

Fig. 125 represents a machinery barge as built by Messrs Haviland & Farmer.

Fig. 125 also shows the filter dust collector, which has been introduced into the exhaust chamber, as well as the water dust collector on the deck of the machinery barge. Undoubtedly these dust collectors are of great advantage, as they will retain the most harmful dust, but it is questionable whether the water dust collector will entirely remove the finest dust.

Messrs Haviland & Farmer claim that by the use of their dust collectors the pistons

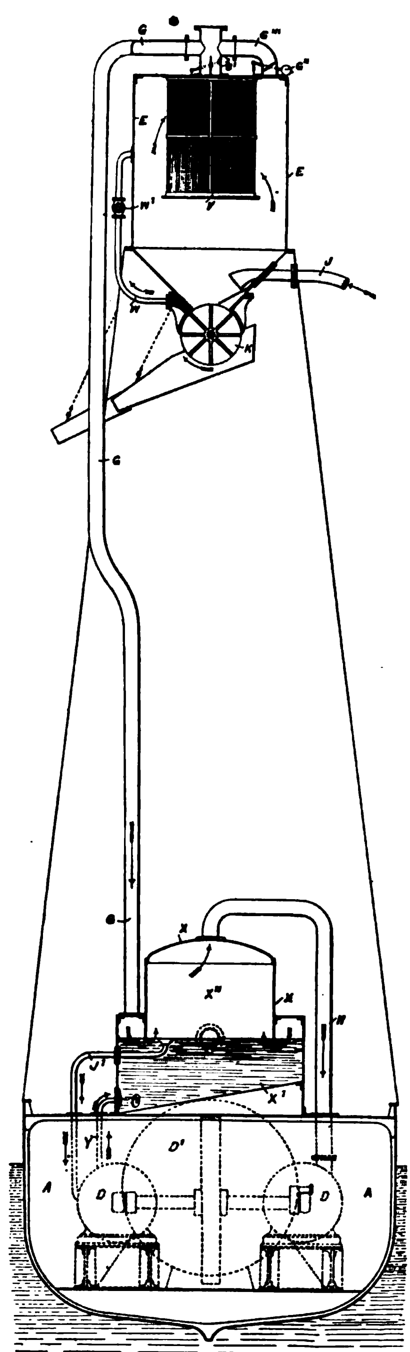


Fig. 125. Machinery Barge Built on Haviland & Farmer's System.

may be fitted with ordinary metallic packing rings, and that metallic valves may be used on the exhausters.

The illustration shows a tank which has a patent gauze chamber which is for the purpose of keeping back coarse dust and chaff, whilst the water dust collector is for the purpose of eliminating the finer particles of dust which are not retained by the filter dust collector. Upon the elevated grain and air entering the vacuum tank E through pipe J, the greater portion of the dust, husks, &c., is prevented by the fine gauze filter V from entering the suction pipe G leading to the fine dust collector X. Some of the coarse impurities are deposited amongst the grain and discharged through the air-lock revolving wheel valve K, and from thence taken by spouts and deposited at the warehouse or into the lighter.

To prevent the scattering effect of the grain through the air as the latter rushes out of the pockets of the wheel valve K, and blows up through the grain as each pocket in turn comes under the aperture in the bottom of the vacuum tank, the air is previously withdrawn from them by a pipe W, the valve W′ being open.

When a winnowing effect is desired for the purpose of withdrawing the dust from the cargo, the valve G′ in the suction pipe connected to the gauze filter is shut, and the valve G″, on the pipe G‴, communicating also with the vacuum pipe and vacuum tank, opened. This allows the dust and husk-laden air to be withdrawn and deposited in the dust collector. The valve W′ is also entirely or partly shut, which causes the air contained in the pockets to blow through the grain as it falls into them. By this arrangement the grain cargo can be delivered, either with a minimum loss of weight, or on the other hand, the dust, husks, &c., may be withdrawn to clean the grain, should this be essential.

X represents the water dust collector, the under part X′ of which is filled with water, sealing the bottom of the vacuum chamber X″. Above this, and communicating with the exhausters D, D, is a further pipe H. The pipe G conducts the dust-laden air from the overhead vacuum tank E to the dust collector X, whence it is drawn by the vacuum into the chamber X″. Through the seal

of water leaving the dust behind, and the purified air escaping into chamber X″, whence it is drawn by pipe H to the exhauster, water is fed into the under part of dust collector X by a small pump. By this arrangement the dusty air is prevented from entering the exhauster. This is very important, as the dust from grain contains a large percentage of silica, which naturally, when conducted into the cylinder, causes wear and tear.

The arrangement of the dust collectors admits of either eliminating the dust altogether, or if need be, returning it to the cargo of grain, so as not to diminish the weight. The dust in the latter case is only held in suspension at the time, and then put back with the discharged grain.

The importance of this improvement is apparent, as merchants have sometimes complained of the loss of weight where pneumatic machinery has been used for unloading cargoes. The air trap employed by this firm consists of a revolving wheel valve (see Fig. 126), instead of the Duckham oscillating valve.

The wheel valve contains eight pockets in its circumference. These fit into a casing, and the wheel is driven by power from the engine at a speed to correspond, so that the capacity of the revolving pockets is about equal to that of the grain discharged from the exhaust chamber. It is obvious that a valve of this description can be made to fit perfectly, and that therefore a loss by leakage is less likely. This air lock has this

Fig. 126. Haviland & Farmer's Air Trap.

additional advantage, that the pockets are much smaller than those in the Duckham air trap. Hence, though the filling of each individual bucket has to be effected more frequently, the amount of air carried into the exhaust chamber is less at each time. Thus the draught is not so severe even if used for the purpose of causing a winnowing effect, while the call upon the exhauster is more uniform. Of course with both the Duckham and Haviland & Farmer air traps the pocket to be filled with grain before going into register with the exhaust chamber is full of air of atmospheric pressure, and it is obvious that the exhauster must remove this air in order to keep the vacuum intact, either directly or indirectly; but the smaller the quantity of air admitted and the oftener, the less will be the strain on the exhauster and the more uniform will be the suction in the supply.

The Haviland & Farmer apparatus is provided with an exhaust pipe by means of which the air can be exhausted from the chamber before it is filled with grain. A similar system of exhaust was in use in the early appliances of Duckham (see Fig. 120). It is difficult to say what effect the discharge of air from the Duckham pocket into the vacuum chamber has, but it would appear that the grain running into the pocket is met by the air expanding from the vacuum chamber, which will not allow of the pocket being filled until the air pressure has been equalised.

The Haviland & Farmer grain suction pipe is illustrated in Fig. 127.

The pneumatic elevator on the blast system erected by Messrs Haviland & Farmer,

which is at work at Sulina on the Lower Danube, has now been reconstructed with the above-mentioned improvements, and is giving great satisfaction, as will be seen by the following figures.

In 1901 the average quantity of grain per month passed through the machine was 19,197 tons. In 1902 the monthly average was 20,450 tons, giving an average annual tonnage for the two years of 237,000 tons. The largest quantity dealt with in any one month was 38,978 tons, but the machine was capable of handling up to 50,000 tons per month. The result of a trial made to test the efficiency of the pneumatic grain elevator in the Lower Danube in 1902 shows that with 375 indicated HP., 160 tons of grain per hour was elevated to a height of 56 feet. The plant was reconstructed to

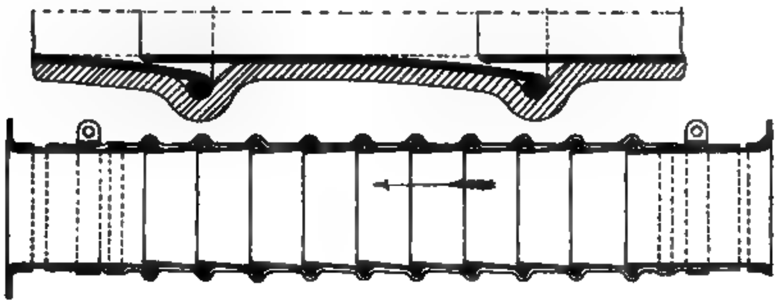


Fig. 127. Haviland & Farmer's Grain Suction Pipe.

the suction system in 1898 and further improved in 1903, after which 181 tons per hour were elevated to the same height with 350 indicated HP., a very satisfactory result.

The latest improvements of Messrs Haviland & Farmer have been protected under the patents taken out in 1902. They include details in connection with the purification of the air and improvements in the handling of the grain pipes. The latter greatly facilitate the working, as the pipes are hinged to the receiving chamber by means of universal swivels, and admit of an easy movement into a variety of positions. They also include a device for packing the pistons of the exhausters by means of water, which is admitted through a hollow piston rod to the body of the piston under pressure, and from thence is allowed to escape through small openings and press against the walls of the cylinders.

CHAPTER XIV.

CONVEYORS DESIGNED FOR SPECIAL PURPOSES, INCLUDING THE BOLINDER TIMBER CONVEYOR, COKE CONVEYORS, AND CASTING MACHINES.

THE conveyors mentioned under this heading have been designed for the purpose of handling material of a somewhat different nature to that usually treated by such means.

The Bolinder timber conveyor has been designed solely for the purpose of conveying timber, and its construction is such as to render this a comparatively easy matter.

Hot coke conveyors, which are also mentioned under this heading, are specially built with a view to enable them to resist the great wear and tear to which they are

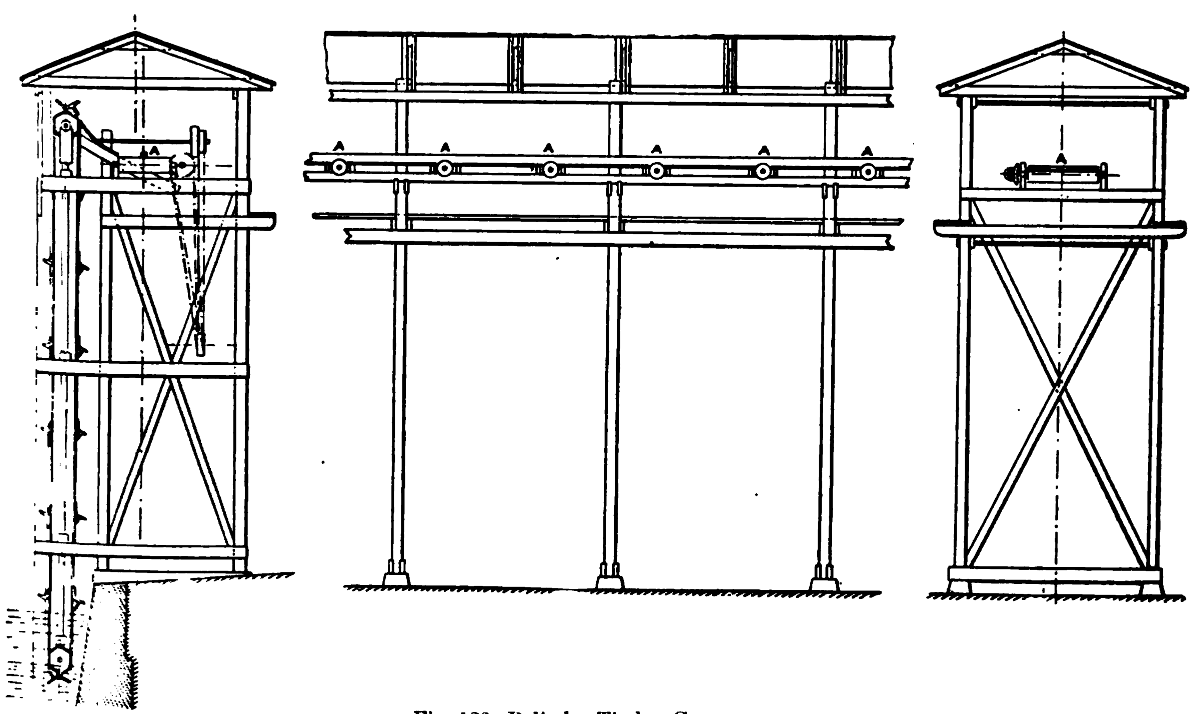


Fig. 128. Bolinder Timber Conveyor.

subjected from the action of the hot coke. Most appliances for the conveyance of coke are to all intents and purposes push-plate conveyors, the construction of which has been specially adapted to handle this material, which is a most difficult substance to treat mechanically.

Casting machines, or more properly conveyors for molten metal, are here described; these are principally used for conveying molten metal from the furnaces.

Timber Conveyors.*—These conveyors cannot be classified under any of the previous heads, but may be more correctly termed continuous rather than intermittent conveyors.

A conveyor of this type is used at the Millwall Docks for conveying boards. It is somewhat on the principle of a band conveyor; but whereas in the band conveyor the band is driven and causes the supporting rollers to revolve, in the Bolinder conveyor the rollers are made to revolve, and thus propel the boards placed upon them. Fig. 128 shows a section through the conveyor on its supporting structure, with the elevators which lift the boards on to the conveyor. It also shows another section and a longitudinal elevation of the conveyor.

The rollers A, A, are of cast iron, and 10 inches in diameter by 2 feet 6 inches long. They are pitched 5 feet apart, and are driven by a small steel shaft about 1 inch in diameter, running the whole length of the conveyor, each roll being geared to this shaft by a pair of bevel wheels with a ratio of about 3 to 1.

The rollers project slightly through the bottom of the trough, in which the boards

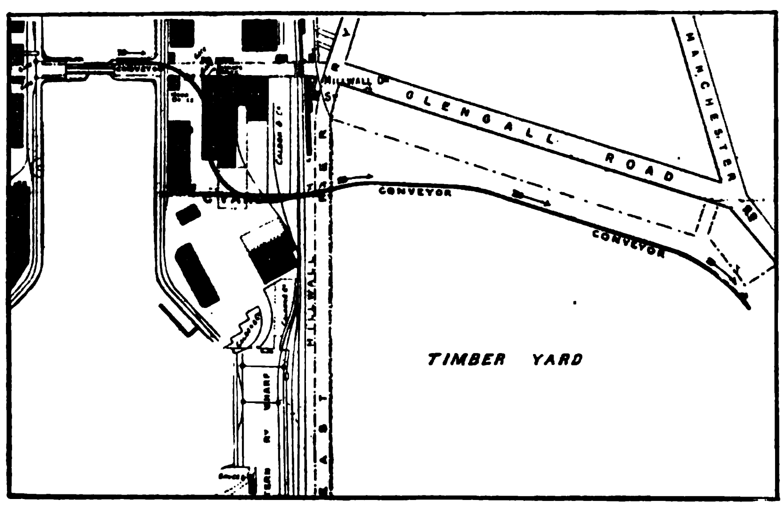


Fig. 129. Bolinder Conveyor at Millwall Docks.

travel at the rate of 150 to 200 feet per minute, the rolls themselves making 60 to 80 revolutions per minute. The boards to be conveyed must be more than 10 feet long, so as always to rest on not less than two rollers.

This conveyor is very simple and effective, the most remarkable feature about it being that its construction admits of its being built in curves as well as in straight lines. The one at the Millwall Docks describes several curves having radii of 170 to 190 feet. The steel driving shaft is sprung into these curves and appears to work well, though no doubt it consumes more driving power than the straight lengths. The conveyor has a separate electro-motor of 5 HP. for every 500 feet of its length, the motor itself being placed half-way. Successive lengths of 500 feet are speeded to convey the timber at 180 and 200 feet per minute respectively. This conveyor will deliver about 200 standards† of 5 in. by 7 in. "battens" in ten hours, and other sizes in proportion.

* See *Timber Trade Journal*, 13th July 1901.

† 1 standard of wood is 120 pieces 12 inches long by 11 inches wide and 1½ inches thick, or its equivalent, *i.e.*, 165 cubic feet of timber. 3·3 standards make up one load.

Fig. 130. Extended View of Bolinder Timber Conveyor crossing G.E. Railway and East Ferry Road.

Fig. 131. Bolinder Timber Conveyor at Work.

Fig. 129 shows a general plan of a portion of the Millwall Docks where the Bolinder conveyor is at work. The line indicated by arrows illustrates the whole length of the conveyor with its curves.

Fig. 130 shows a photographic view of the same conveyor.

Fig. 131 shows the men placing the planks on the elevator, which in turn deposits them on the conveyor.

Fig. 132 represents the delivery appliance by means of which the planks are lowered to the ground. This appliance is movable and runs on a single rail, so that it can be put into any position.

Fig. 133 gives a photographic view of the same lowering device.

A conveyor is being built by Messrs Bolinder on similar lines, but movable on wheels for use in timber yards. Fig. 134 illustrates this appliance, which practically explains itself, it being on the same lines as the conveyor just described. Its principal feature is this, that it is built in such a way as to allow of its temporary erection at different parts of the timber yard. The time taken in connecting, say 100 feet of this conveyor, would be about twenty minutes. The conveyor is built in sections (one of which is represented in the illustration). They are each 20 feet long, and are joined together by steel cotters. The respective lengths of shafting are also coupled together, the end of each length being square, and fitting into a square socket on the succeeding length of shafting. Conveyors of this construction will deliver about 100 standards of 3 in. by 7 in. "battens" in ten hours, while the capacity on other sizes of timber would be in proportion.

The same firm have also recently introduced a new timber conveyor which appears to be a great improvement on the old one. It consists of an endless chain which runs over two terminal pulleys of suitable design. The chain itself consists of a series of rollers, the distance from roller to roller being about 3 feet.

Fig. 135 shows details of the chain; also special link with rollers.

Fig. 136 shows a portion of the conveyor as mounted in the timber yard.

Fig. 132. Lowering Appliance in connection with Bolinder Timber Conveyor.

It will be readily understood that as the conveyor is set in motion, the rollers, which run on supporting timbers, revolve, whereupon the timber to be conveyed is not only carried by the rollers, but is also pushed forward by virtue of the revolution of the rollers, so that its progress is considerably accelerated. The chain has a speed of 90 feet per minute, and the timber is conveyed practically at 180 feet per minute. These conveyors are built in lengths of 1,000 feet, with one driving gear. Such a length is said to take 6 HP. to drive. The total length of such conveyors, composed of coupled units of 1,000 feet, is unlimited, and if driven by electro-motors the driving arrangements will require very little preparation. They pass round curves with a radius of not less than 150 feet for deals 30 feet in length by 1 foot wide. Longer deals would require a greater radius in proportion.

In addition to the advantage already mentioned of greater speed of delivery, it has the further advantage that both top and bottom strands can be used for

conveying. It is obvious that when two or more conveyors are coupled together the timbers will readily travel from one length to another; but where the lower strand is also to be used for conveying, small auxiliary conveyors are used to remove the timber from the lower strand past the terminals to the lower strand of the next conveyor.

The capacity of this new conveyor is 160 standards in ten hours.

There are many other conveyors in use for conveying timber, principally in the

Fig. 133. Photographic View of Lowering Device in connection with Bolinder Conveyor at Millwall Docks.

timber districts of America and in the vicinity of the Baltic Sea. These are not, however, individually described, as they do not present any new features. They are all more or less of the same type as the trough cable conveyor, and work in pairs or in greater numbers. The attachments are so pitched as to simultaneously engage with beams or planks, and so convey them up inclines or in a horizontal direction. Very frequently pitch chains are used instead of cables, when the attachments are not in the form of discs, but rather in the shape of claws.

Coke-handling Plant of the Gaythorne Gas-works.*—Probably the first conveyors erected in this country for the purpose of conveying hot coke were those at the Birmingham Gas-works and at some minor works. The first installation, however, of any considerable capacity was that erected at the Gaythorne Gas-works, Manchester. It was the first conveyor of its kind which conveyed the contents of inclined retorts,

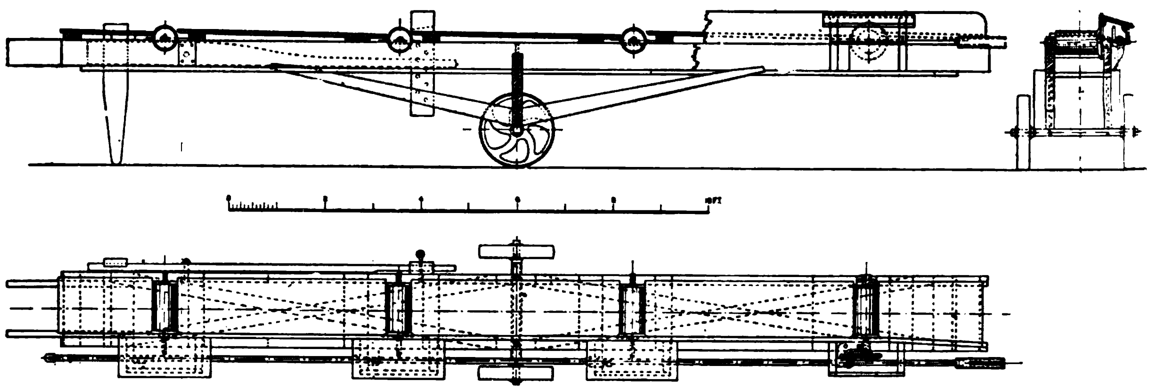


Fig. 134. Movable Timber Conveyor.

which means that a charge of about 4½ cwts. of coke is deposited in the conveyor and has to be removed by it in fifteen seconds.

The conveyor used is that illustrated in Figs. 47 and 48 (see page 47).

It was necessary to provide a conveyor of sufficient capacity to clear the coke away

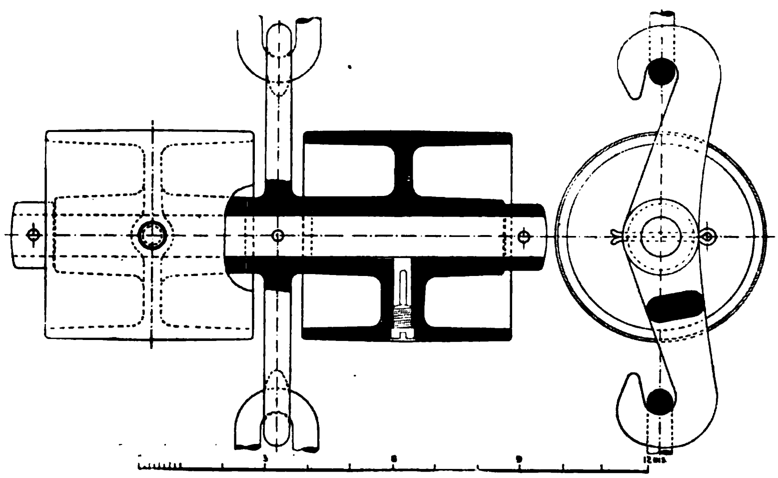


Fig. 135. Latest Type of Bolinder Timber Conveyor.

as fast as it left the retorts. The operation of conducting the coke to the stock heap in the yard was at the same time taken into consideration. The conveyor trough is 24 inches wide and 9 inches deep, and it extends the whole length of the retort house, and after passing out at one end and arriving at the delivery shoot, the chain returns

* See article by G. E. Stevenson in *Feilden's Magazine*, Dec. 1899.

overhead on rollers and sprocket wheels carried on brackets fixed to the upright supports of the retort benches. The elevator raises the coke after it is brought out of the retort house to a screen fixed above the storage hoppers. The elevator differs from those of the ordinary type in having the buckets close together and mounted on wheels, each bucket being provided with a pair of suitable guide rollers.

The screen at the top separates the "breeze" from the coke and delivers the latter on a metal band conveyor of ordinary construction, by which it is carried to the store

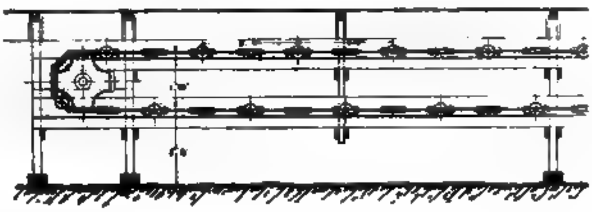


Fig. 136. Latest Type of Bolinder Timber Conveyor as used in Timber Yards.

heap. A series of ploughs is arranged along this conveyor, and the coke can be pushed off the conveyor and deposited on the heap by the lowering of the plough.

The principal difficulties met with in handling coke mechanically arise from the rapid wear and tear of different parts of the machinery owing to the cutting nature of the coke breeze, which causes excessive friction and undue strain on the machinery. Portions of the plant are also liable to rapid deterioration from the action of the hot coke.

In the Gaythorne installation these difficulties have been overcome to some extent. The chain in the trough works with a minimum of friction, the only parts in contact

Fig. 137. Müller Hot Coke Conveyor.

being the sliding blocks and the rails, which are both renewable. The parts being of cast steel, are not affected by the hot coke, which is, however, quenched by copious streams of water immediately it falls into the conveyor.

The "Müller" Coke Conveyor.—A well-designed form of conveyor for coke ovens is the work of Mr Joseph Müller, of the Matthias Colliery, at Essen, in Germany. This appliance is intended to take the coke as it comes from the ovens in a red-hot state, and at once quenching it in water, to allow it to dry and be discharged on a sieve or grate, and finally to load it into waggons or boats in one continuous and automatic operation.

A diagrammatic view of the apparatus by which this is accomplished is shown in Fig. 137. In front of the outlets of the coke ovens there is a tank B, which is kept full

of water. The right end of the tank has a sloping side. In this tank is placed the carrier and conveyor, which consists of a strong frame on wheels which runs on three transverse rails, allowing the whole apparatus to be moved crosswise in the tank. Strong side beams of plates and bars form the frame of the carrier. Crossbars and stays serve to strengthen it laterally. That part of the carrier frame near the oven is built horizontally, and is completely immersed in the water. The other part rises gradually, and at its further end is entirely out of the water, and so high that there is sufficient room below it for a sieve or grating at S, which may be built in one with the carrier, or may form a separate part of the apparatus. The sieve or grating may be made with movable bars, or the latter may be fixtures. When arranged separately from the transporter frame, the sieve may run across the whole width of the tank.

The carrier band consists of two chains, one at the right and the other at the left edge. They are connected laterally by means of bolts, which bolts form at the same time the axles for the carrier wheels upon which the chains are carried forward.

Fig. 138. Wellman Seaver Morgan Coke-handling Plant.

Plates riveted or bolted on the chains, and each reaching from one side to the other, of exactly the width of the pitch of the chain links, form together a continuous platform.

The coke coming from the furnace in a hot glowing state, is pushed directly upon the carrier chain into the tank, where it is quenched and slowly carried forward. At the further end it is raised out of the water, and upon the rising part of the carrier chain the water can run off and the coke is dried, the heat contained in it quickening the drying process, so that it arrives almost dry at the end, where it is thrown automatically upon the grating, and after the breeze has been eliminated by the latter the coke is discharged into waggons.

The transporting band or table moves between two inclined side shields V, which are so fixed to the carrier frame that the plates pass below the lower edge of the shields, thus preventing the escape of any coke. The rails or guides for the chain wheels are formed by the channel irons which are parts of the carrier frame. The upper horizontal flange carries the upper chain, while the lower horizontal flange carries the lower or returning chain.

When a coke oven has been emptied, and the coke from it has been quenched, conveyed away and loaded, the whole apparatus is shifted sideways in front of another oven ready for discharge.

Wellman Seaver Morgan Coke-handling Plant.—The installation shown in Fig. 138 is built by the Wellman Seaver Morgan Co., and is intended to receive the coke as it is pushed out of the ovens, and after quenching, deposit it in the railway trucks. It consists of the framework AA mounted on wheels, between the ends of which a movable rectangular receptacle B is placed, at an angle of about 45 degrees, the up-and-down movements of which are governed by the guides D, D. These permit of the receptacle B rising perpendicularly for only a portion of its travel. It then moves towards

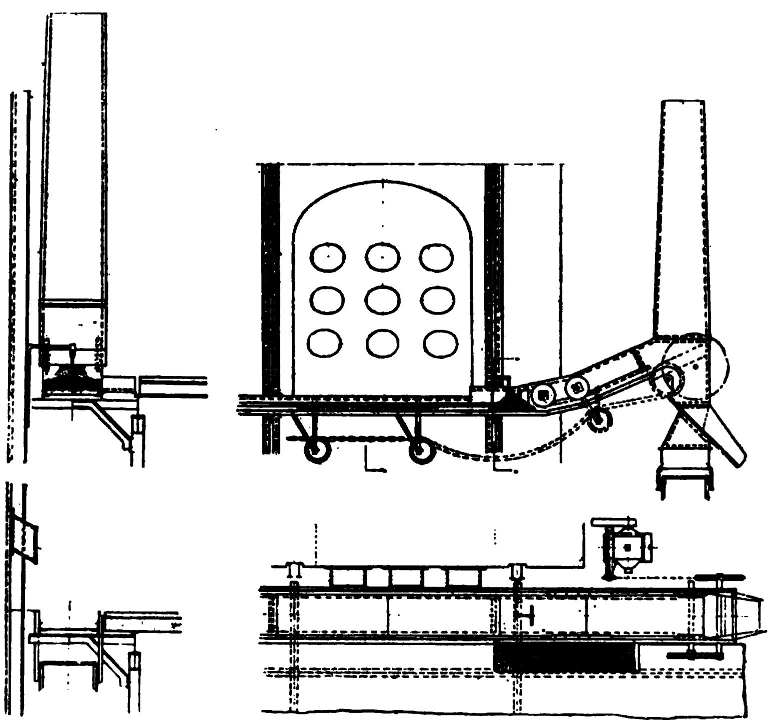


Fig. 139. De Brouwer Conveyor.

the truck, where the contents can be deposited by opening the delivery door. The plant is driven by electricity taken from a main above the frame A.

The De Brouwer Conveyor.—This conveyor, which is one of the most successful appliances of its kind, is illustrated in Fig. 139. It consists of an open rectangular wrought-iron trough, in the bottom corners of which run the upper strands of two driving chains, joined at intervals by connecting bars.

The chains themselves are flat, and as they run upon their edges, neither take up much room in the trough, nor present much wearing surface. They run upon renewable flat iron bars, and are protected by two small angle bars riveted to the trough, which are visible in the drawing.

The return or lower strand runs over a series of guide pulleys, three of which are shown in the illustration, and are fitted with plumbago lubricators. This conveyor can be used horizontally, or to work up an incline of 30 degrees.

As it leaves the retorts, the red-hot coke is directed into the trough by a deflecting plate. The connecting bars soon come in contact with the pieces of coke, and direct them forward in the same manner as the plates in the push-plate conveyor. At intervals the coke is quenched by a spray of water. The conveyor is erected in a horizontal position, except at the delivery end, which is inclined in a slightly upward direction. This upward movement is for the purpose of ensuring a certain amount of water in the trough, so that neither the chain nor the connecting bars ever suffer from contact with the hot coke.

The illustration shows the apparatus both in plan and elevation, and also gives two cross sections of the same. The chequered portion of the plan represents the covering of a small water tank (also visible in one of the cross sections). This is for the purpose of equalising the water level in the trough. The conveyor when at work pushes the

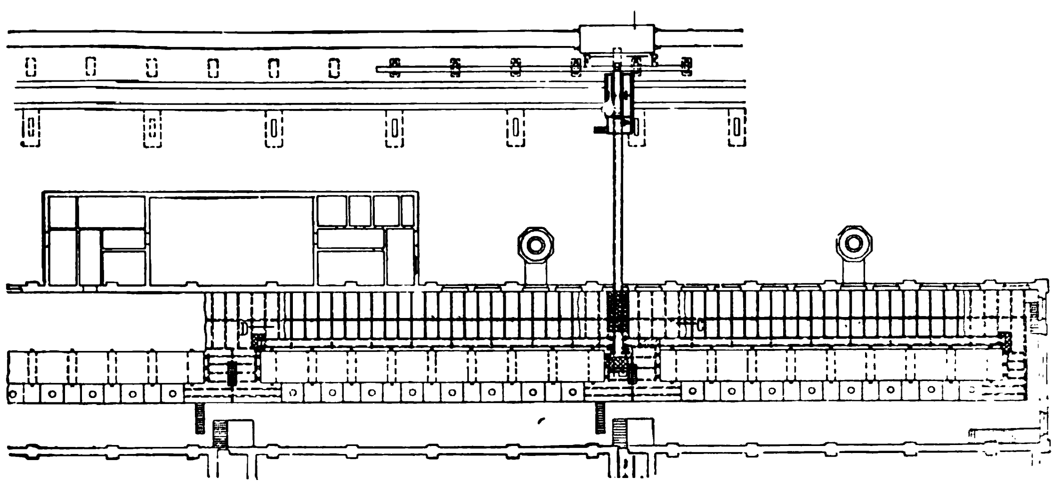


Fig. 140. Plan of Hot Coke Conveyor at Zürich Gas-works.

coke as well as the water in front of its bars. At the beginning of the incline the water is first sent slightly uphill, but immediately flows back, and completes the quenching process, which is also greatly assisted by the final spray shown in the illustration. In order to prevent the water supply in the conveyor from running short, owing to any neglect of the attendants, the conveyor is so arranged as to automatically turn water on, and off, that portion of the trough which is fed with coke. The inclined portion of the conveyor at the delivery end is covered by a lid, in connection with an uptake, and by this means the vapours caused by the quenching of the coke are drawn away.

The electro-motor driving the conveyor is indicated in the illustration, which also shows the delivery shoot for the quenched coke.

Hot Coke Conveyors of the Gas-works, Zürich.—Figs. 140 and 141 show an installation on the same principle, erected by the Berlin Anhaltische Maschinenbau Aktien-Gesellschaft for the Gas-works at Zürich, Switzerland.

The illustrations consist of plan of the retort house, yard, and a portion of the coke store. They also give a cross section through the classifying conveyor in the coke store.

This installation consists of two De Brouwer conveyors, situated in front of a double range of retorts. These conveyors deliver the coke into a third conveyor running at right angles. This in turn delivers into the swinging conveyor which is at the same time used for sifting purposes, classifying the coke into dust, small pieces, and large pieces. The large pieces can either be accumulated in the store, or loaded direct into the trucks, as shown in the illustration.

The "Marshall" Hot Coke Conveyor.—One of the latest hot coke conveyors is that at the Danish Gas-works, Copenhagen, which is illustrated in Fig. 142.

It consists essentially of a wrought-iron trough to the sides of which are fixed a series of guide rollers upon which the two conveyor chains run. The chains consist of

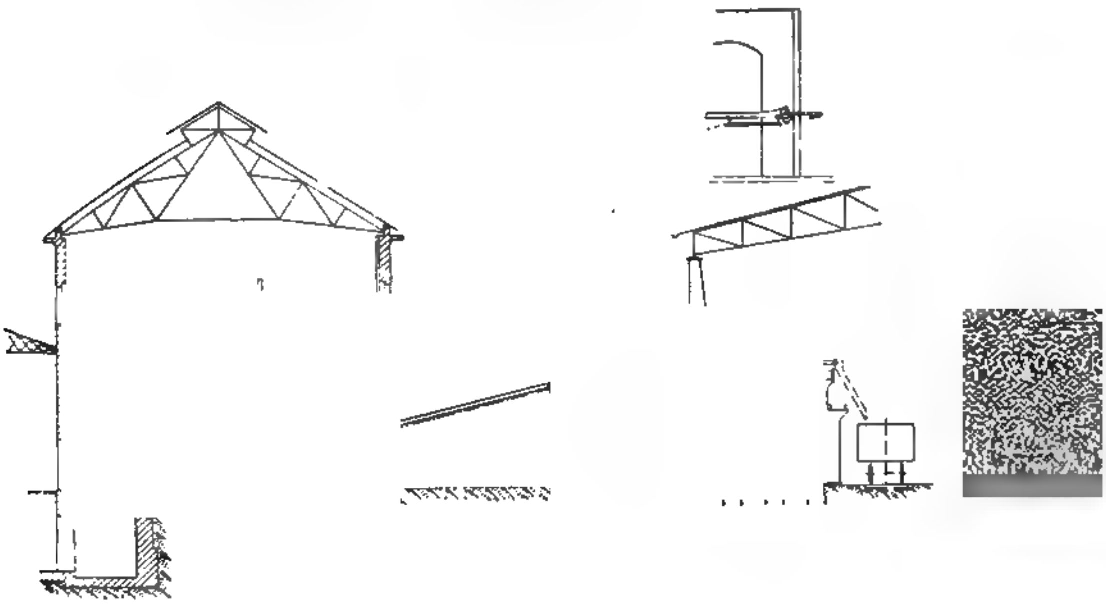


Fig. 141. Elevation of Hot Coke Conveyor at Zürich Gas-works.

long wrought-iron links of a horse-shoe shape which are sufficiently far apart to be outside the trough. Both guide wheels and chains are protected by a sheet-iron covering. Attached to each alternate link is the metal cradle for carrying the coke, the bottom of which is formed either by a series of round iron bars (as shown in A), or by a series of flat iron bars kept at their proper distance by pieces of gas-pipe.

Both methods A and B are shown in cross section as well as in plan. From the latter the construction of the links of the chains is also clearly visible. The trough is kept partially filled with water so that the portion of the cradle which carries the coke is always well submerged. The conveyor is driven by a hexagonal terminal pulley as shown in the illustration, and the coke is discharged at the moment that the chains with their cradles are moving round it.

Hot Coke Conveyors of the Gas-works, Bâle, Switzerland.—Fig. 143 shows another coke-conveying installation in which the De Brouwer conveyor has been

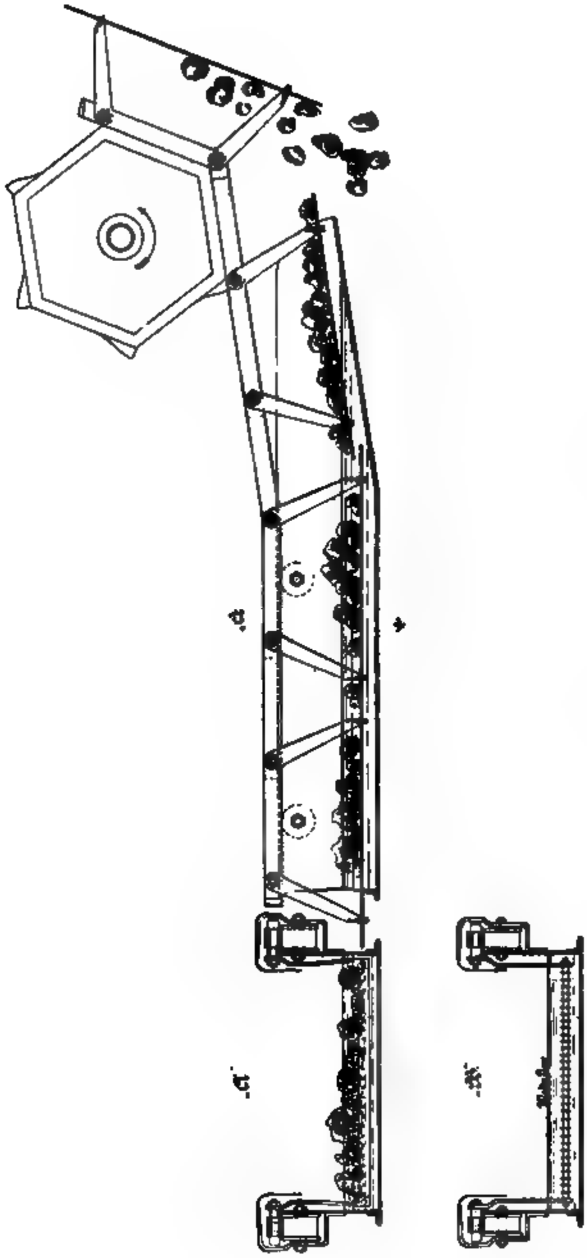


Fig. 142. Marshall Hot Coke Conveyor.

used. This installation was also built by the Berlin Anhaltische Maschinenbau Aktien-Gesellschaft, and is shown here to illustrate the steep incline at which some of these conveyors are worked, and also to show that the coke can by this arrangement be thrown off the conveyor at any desired point.

Fig. 144 shows the inclined conveyor on a larger scale. There are no less than five points at which the coke can be thrown off either to railway trucks or into vehicles,

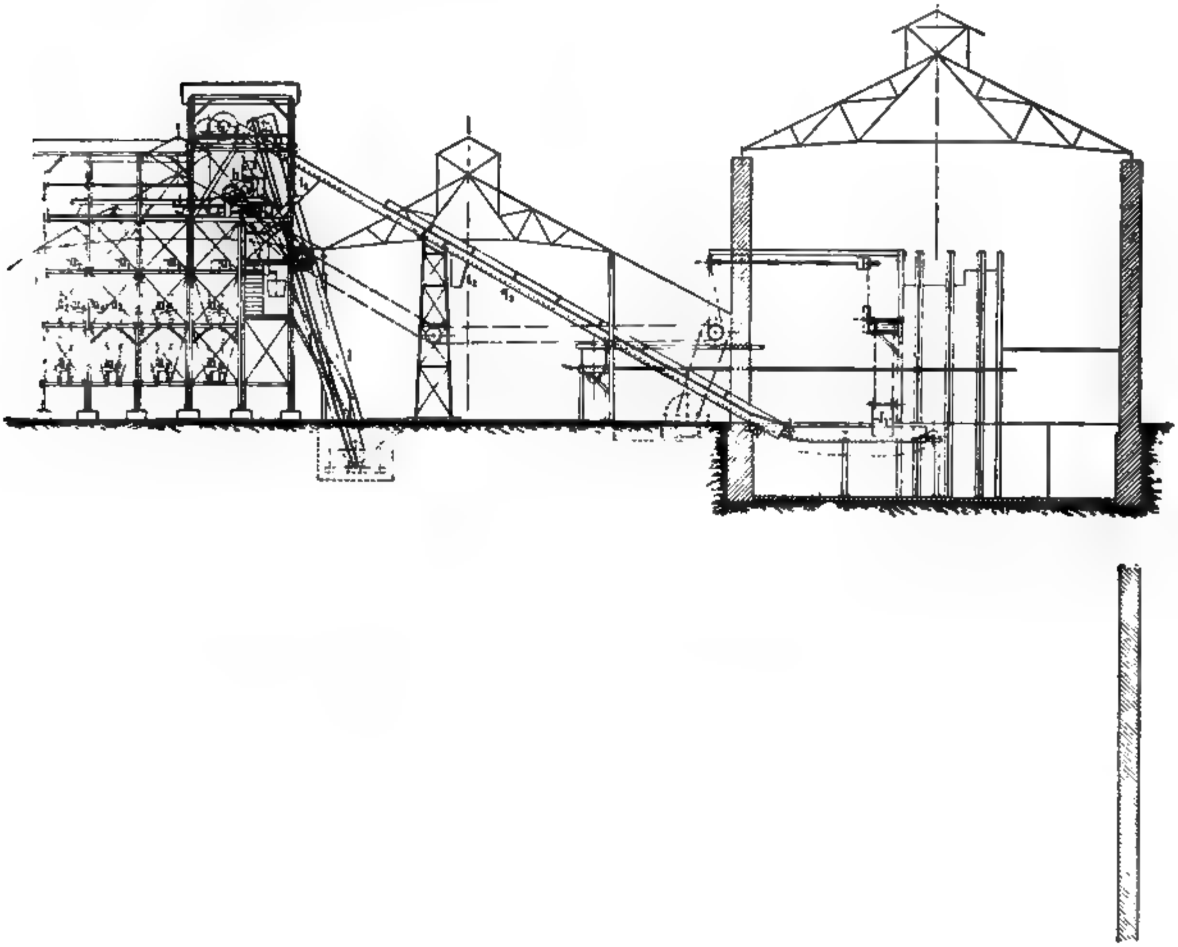


Fig. 143. Plan and Elevation of Cross Section of Hot Coke Conveyor at the Gas-works, Bale, Switzerland.

or into a series of silos, or it may be fed on the swinging conveyor which is used to classify the coke into different sizes.

The De Brouwer conveyors are visible both in plan and elevation. Those marked f_1 and f_2 discharge their load into the inclined conveyor f_3, which ascends at an angle of nearly 30 degrees.

The exit t_1 is for withdrawing the coke without classification, and the exit t_2 serves the purpose of withdrawing the coke which has been produced during the

night, and storing it on the ground in a heap. This method has the advantage that the night coke can thus be stored, obviating the necessity of running the machinery in the coke store during the night. The coke thus accumulated is lifted in the morning by the elevator *l* to the coke-breaker *h*, and is then classified by a sifting swinging conveyor *i* into different sizes and deposited into hoppers u_1, u_2, and u_3. The coke withdrawn during the daytime is run to the terminal of the conveyor *f*, and is thence spouted to the coke-breaker *h* and duly classified. There is this advantage in storing the coal in the hoppers u_1, u_2, and u_3, that from the top hoppers, u_1, elevated railways can be fed; hoppers u_2 are high enough to discharge their contents into railway trucks; while from u_3 the coal can be withdrawn into lower receptacles such as hand-carts, &c.

Hot Coke Conveyor at the Gas-works, Mariendorf.—The installation, Fig. 145, is very similar to the previous one, and is also the work of the Berlin Anhaltische

Fig. 144. Inclined Conveyor at Bale Gas-works.

Maschinenbau Aktien-Gesellschaft, for the Gas-works, at Mariendorf, of the Continental Gas Association. Although differing in certain details and dimensions, this installation is so similar to the one just described that it requires no further comment, the drawing being self-explanatory.

The "Merz" Hot Coke Conveyor.—This appliance is similar to the De Brouwer conveyor, but has been modified in certain details. It was introduced by Herr Merz, Managing Director of the Gas-works, Cassel, Germany, who maintains that the round or octagonal bars of the De Brouwer conveyor have this defect, that they do not have sufficient hold on the coke, which is therefore apt to slip back over the bar. He also contends that owing to the short length of the links it is difficult to obtain chains of absolutely equal lengths. He therefore designed the conveyor as shown in Figs. 146 and 147. This apparatus combines gentle action together with great durability and the greatest facility in replacing broken parts.

Fig. 145. Hot Coke Conveyor of the Mariendorf Gas-works.

Fig. 146. Merz Hot Coke Conveyor.

Fig. 146 shows the construction of the conveyor, but here, instead of the chains running in the bottom of the trough, they are concealed in a suitable groove at the top. Moreover, the bars connecting the chains are replaced by cast-iron rakes which are also supported by rollers. The prongs of the rakes being set at an angle, relieve the conveyor trough of a portion of the weight of the coke, and thus reduce the wear and tear. The principle can best be seen from the perspective view, Fig. 147, which explains itself.

Fig. 147. Photographic View of Merz Hot Coke Conveyor at Cassel Gas-works.

The conveyor is driven at the opposite end to that represented in the illustration by an electro-motor. This conveyor is built in two different types, namely, with the supporting rollers at both ends of the rakes, or with the supporting rollers fixed to the trough, so that the chain travels over the rollers.

Fig. 146 shows the latter construction; Fig. 147 the former.

The trough is made of cast iron, and consists of sections in lengths of about 4 feet 8 inches, and joined together by flanges.

It is stated that the power consumed by the conveyor at the Cassel Gas-works,

which is 190 feet long, is between 3 and 4 HP. when the appliance is in full work; this, however, appears almost incredible.

Coke-breaking and Sorting Plant.—Fig. 148 shows on a large scale a coke-breaking and storing plant by the Berlin Anhaltische Maschinenbau Aktien-Gesellschaft. The illustration almost explains itself. The coke is brought to the elevator by narrow-gauge trucks, is taken up and passed through the coke-breaker into the swinging conveyor, which is fitted with perforated plates, and classifies the coke into four sizes. The capacity of such a plant is practically unlimited.

Fig. 148. Coke-breaking and Sorting Plant. (The dimensions are millimetres.)

Hot Coke Conveyor of the New Conveyor Co. Ltd., Smethwick, Birmingham.—This conveyor consists principally of a water-tight trough with tray plates attached to a single chain. The plates fit closely, and are made from 18 to 24 inches wide, being 13½ inches long, with 1 inch joggled down at one end to receive the flat front part of the succeeding plate. An improvement has been made in which a steel chain, with steel bushes fastened to the inner links and steel pins secured in the outer links, is used in substitution of the old design of flat and round chain. Rollers have been adopted on each side of the chain carried on brackets attached to the under side of the conveyor plate. These form the carriers for the plates and chain, and being run in water, require no oiling. With the old pattern of flat plate extending right across the trough, separate rollers were required to carry the return strand, these

being placed 4 feet apart, each consisting of a spindle of $1\frac{1}{8}$ inch diameter reduced at the ends to $1\frac{1}{4}$ inch, and revolving in well-lubricated bearings attached to the return angle iron of the conveyor framework. On a conveyor of this description, however, there is a certain, though small, knuckle movement every time the plates pass over the rollers. This is due to the slackness of the chain, which allows the plates to sag between

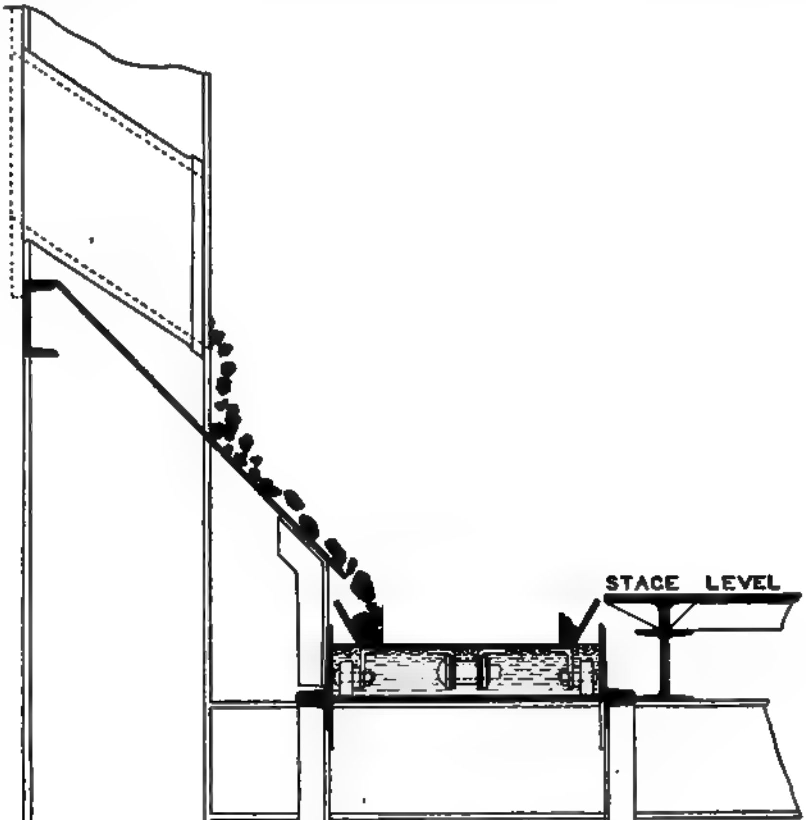


Fig. 149. Little's Type of Conveyor.

the rollers. To overcome this a patent was taken out by A. Little, details of which are shown in the illustration, Fig. 149.

In this design a steel chain was used with side rollers fixed to every third plate, the plates being made in the shape of a tray, which gave clearance between the tray plate and the roller, and enabled these to be threaded on to the return angles, so that the rollers which formerly carried only the top strand of the conveyor now also carry the return strand. The water-tight trough is of course still used, but is reduced in height, being made with side angles instead of channel irons. Thus the coke delivered direct

from the retorts, as formerly, is handled in the conveyor without any buckling of the plates taking place.

The conveyor works noiselessly and requires but little attention during operation. The chain used has a breaking strain of 29 tons, and should wear well.

The plates are made $\frac{1}{4}$ inch in thickness, and joggled as previously described. The carrying brackets are made of manganese steel, either in one piece with a spindle, or with angle iron and separate pin as shown. The rollers are $2\frac{3}{4}$ inches diameter of manganese steel with $\frac{5}{8}$ inch hole. The framework is built of any section angles so as to suit the width of the conveyor adopted, but in all cases rubbing strips are fitted on the return angles to take up any side play on the return strand of the conveyor.

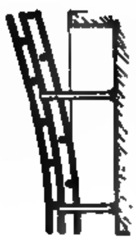


Fig. 150. Elevation of Hot Coke Conveyor at Dumbrick Pavell.

Coke Conveyors at Dumbrick Pavell.—These conveyors are 3 feet wide, and 392 feet 6 inches long, from centre to centre of terminals. The trays are made of $\frac{1}{4}$-inch mild steel plates with edges turned up to form sides. Each tray is riveted to a manganese cast steel driving link 15 inches pitch, and the links are coupled together with pins of $1\frac{1}{4}$ inch diameter. On every third tray is bolted an axle with two wheels, each of 6 inches diameter. The axles are made of mild steel, the ends of which are lapped with blister steel and welded. The ends are machined, bored, hollowed, and hardened. A $\frac{5}{16}$-inch hole communicates with the inside and outside of the ends of the axles. The wheels are of cast iron bored out to fit the ends of the axles, and kept in position with collar on the inside, and nut and washer on the outside. The hollow ends of the axles are lubricated by viscous lubricant, a brass plug being screwed in the end. Lubrication is effected by a boy standing at the side of the conveyor and giving each brass plug a turn with a spanner, which causes the lubricant to flow to the outside of the axle. The wheels run on rails supported on girders. The driving drums are of cast steel and hexagonal with renewable teeth. The conveyor has a speed of 30 feet per minute, but only

works intermittently. At present it conveys 150 tons of coke per twenty-four hours.

Fig. 150 shows an elevation of the installation.

Figs. 151 and 152 give an elevation and a cross section showing the conveyor on a larger scale.

Coal and Coke Handling Plant at Margate Gas-works.—Figs. 153 and 154 show two instances in which the patent swinging conveyor is used for conveying coal and coke in gas-works.

Fig. 153 shows the coal store, under which are fixed two swinging conveyors at right angles to each other. These bring the coal from the store to the elevator, which feeds the hoppers over the inclined retorts. The conveyors are 24 inches wide, and have a capacity of 20 tons of coal per hour.

Fig. 154 shows the coke-handling plant. The coke as it leaves the retorts falls into cage-like trucks, where it is quenched by means of a spray of water. These trucks are afterwards emptied into the hopper (shown in the illustration), which conveys the coke to the elevator, delivers its load into a push-plate conveyor and thence to a coke-breaker, and a screen which eliminates the dust. The coke is then either deposited in a series of hoppers from which it can readily be loaded in cars, or it is conveyed along the swinging conveyor to fill up the coal heap in the yard.

Fig. 155 shows a photographic view of the same conveyor used for depositing coke in the yard of the gas-works.

The conveyor is fitted with a number of outlets which allow the coke to escape at any portion of the trough.

Casting Machines.—Casting machines are of the nature of travelling bucket conveyors, being practically conveyors for the reception of molten metal. They are largely used in the United States, where about 50 per cent. of the pig iron produced, that is about 6,000,000 tons per annum, is handled by these machines.

The chief advantages of mechanically casting and conveying pig iron consists in an enormous saving of labour, and also in the production of sandless pigs. In America such pig iron commands a premium of 1s. to 1s. 6d. per ton above pigs cast in the ordinary way, because melting more easily, it requires less fuel in the cupola. Mechanically cast pigs are smoother and cleaner, and of a more uniform size. Again, any waste in the casting process by runs of pig-bed scrap is avoided, while it is also claimed that such iron is more uniform and homogeneous. Further advantages are claimed in that the furnace can be tapped whenever it is most convenient, while the whole output is cooled and delivered into trucks without being touched by hand.

Of late years casting machines have been brought into use in this country and on the Continent. Being to all intents and purposes conveyors, they are used for the purpose of receiving molten metal, and delivering at the opposite terminal the pig iron into railway trucks.

As yet only a few of these installations are at work in this country, the first being probably that erected at the works of the Millom and Askam Hematite Co., Millom, who adopted the "Uehling" machine. The second plant was that introduced at the works of the Palmer Shipbuilding and Iron Co., Jarrow-on-Tyne, who adopted the "Heyl and Patterson" machine. These two machines are similar in design, the principal difference being that in the case of the "Heyl and Patterson" machine the pigs are cast in moulds whilst partly submerged in water. There is also a minor detail in the device adopted

for preventing the adhesion of the pigs to the moulds. To guard against this the moulds are in the "Uehling" process coated with a spray of lime water, whilst in the "Heyl and Patterson" machine they are coated with soot.

There are two further types of casting machines, the "Ramsay" and the "Hawdon." The former is unlike either of the two first-mentioned appliances, in so far as the moulds are placed round the circumference of a large revolving table.

The "Hawdon" machine is partly in a straight line and partly in a circular form.

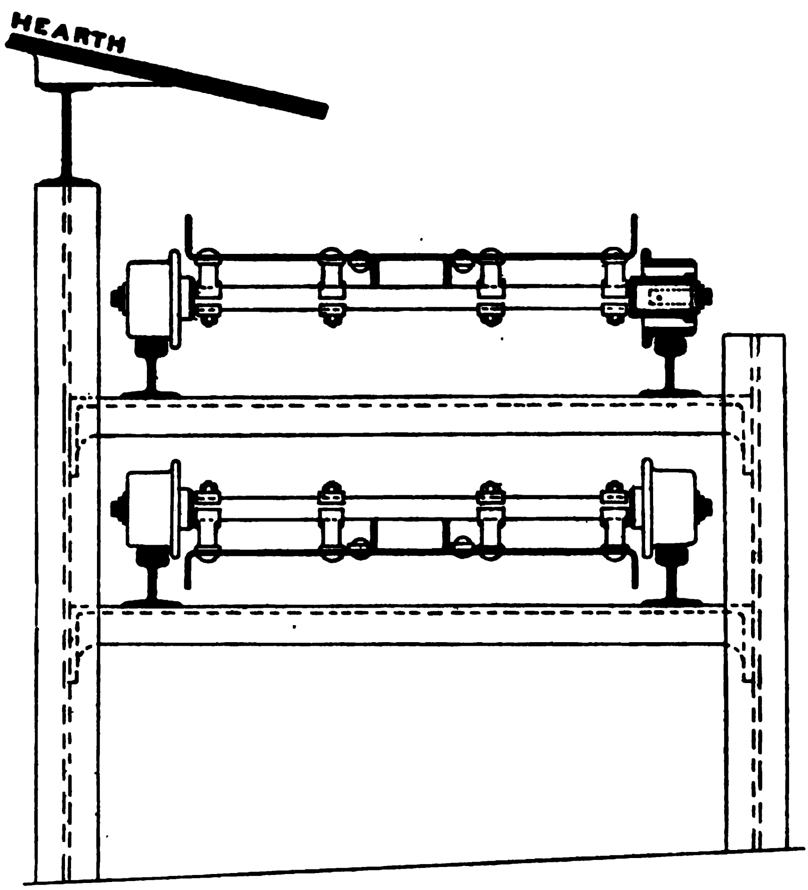


Fig. 151. Cross Section of Conveyor at Dumbrick Pavell.

Several "Hawdon" casting machines are at work in this country and on the Continent, as well as in America.

The great difficulty in the mechanical handling of molten metal lies in the enormous weight of the metal, moulds, chains, &c., to say nothing of the great heat. Such machines must be exceedingly strong and substantial, that they may suffer as little as possible from the heat to which they are subjected and from the weight they have to carry. The expansion of parts of these machines, caused by the heat, the resultant excessive wear and tear, as well as from the lack of lubrication, was found a serious obstacle by the first builders of such machines.

The "Uehling"* Casting Machine at Millom Iron-works.—One of these machines was erected at the works of the Millom and Askam Hematite Co., Millom, in 1898. Fig. 156 shows a general view of it.

Fig. 156A is a plan and elevation of the whole installation.

Fig. 157 shows the feed terminal on a larger scale.

Fig. 158 shows the point at which the pigs are removed from the casting to the cooling conveyor.

The primary object of this machine is to minimise labour in the handling of blast-furnace products. The liquid metal is drawn from the furnace into pots which convey the molten metal to, and distribute it over two strands of moving moulds. Each strand consists of about 260 moulds, and is about 125 feet long. The moulds travel upwards at an incline of 9 degrees, and are carried over sprocket wheels at each end. The conveyor travels at such a rate as to give each mould ten minutes to pass from end to end. This allows the iron sufficient time to solidify before reaching the other terminal. The solid pigs are then precipitated down two chutes leading to the tank of a third conveyor, which is nearly 100 feet long. This third conveyor travels in a tank for a distance of

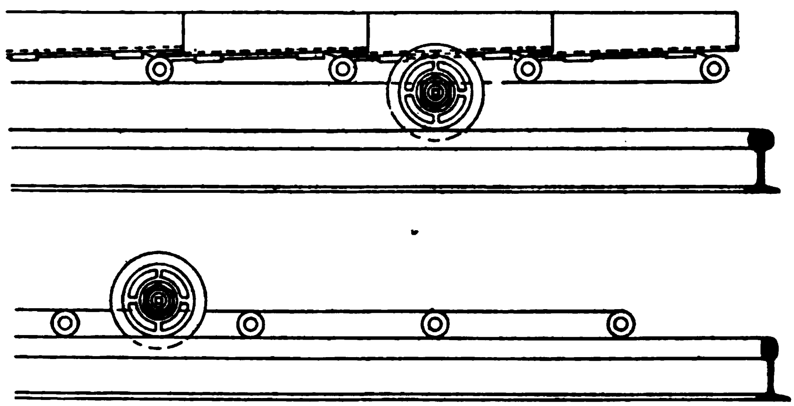


Fig. 152. Elevation of Conveyor at Dumbrick Pavell.

about 70 feet, the water being deep enough to cover the pigs as they lie on the conveyor, which is one of the metal band type. The pigs are carried through the tank, and are raised at the other end to a sufficient height to enable them to be conveniently lowered into railway trucks. It will thus be seen that the operations of casting and conveying the pig iron are effected without any manual labour. The different charges of the furnace being successively cast with this machine, the moulds are kept thereby at a low red heat.

To prevent the metal adhering to the moulds, they are coated by a spray on their return journey to the pouring pot. Fig. 159 shows the way in which this is performed.

The appliance consists of a V-shaped tank in which are placed two sets of spray pipes. A 1-inch gas-pipe is led from the air compressor to the spray pipes, which are operated by compressed air. The pipes are fitted with a spray nozzle on the lower or

* See *Engineer*, 4th August 1899; *Engineering and Mining Journal*, 5th January 1901; *Iron and Coal Trade Review*, 25th November 1898 and 2nd June 1899; *Stahl und Eisen*, 1897, No. 16; 1898, No. 13; 1900, No. 1.

suction end. The apparatus is stopped or set to work by a lever in the pouring shed which is connected by a small chain to a similar lever. This is for the purpose of

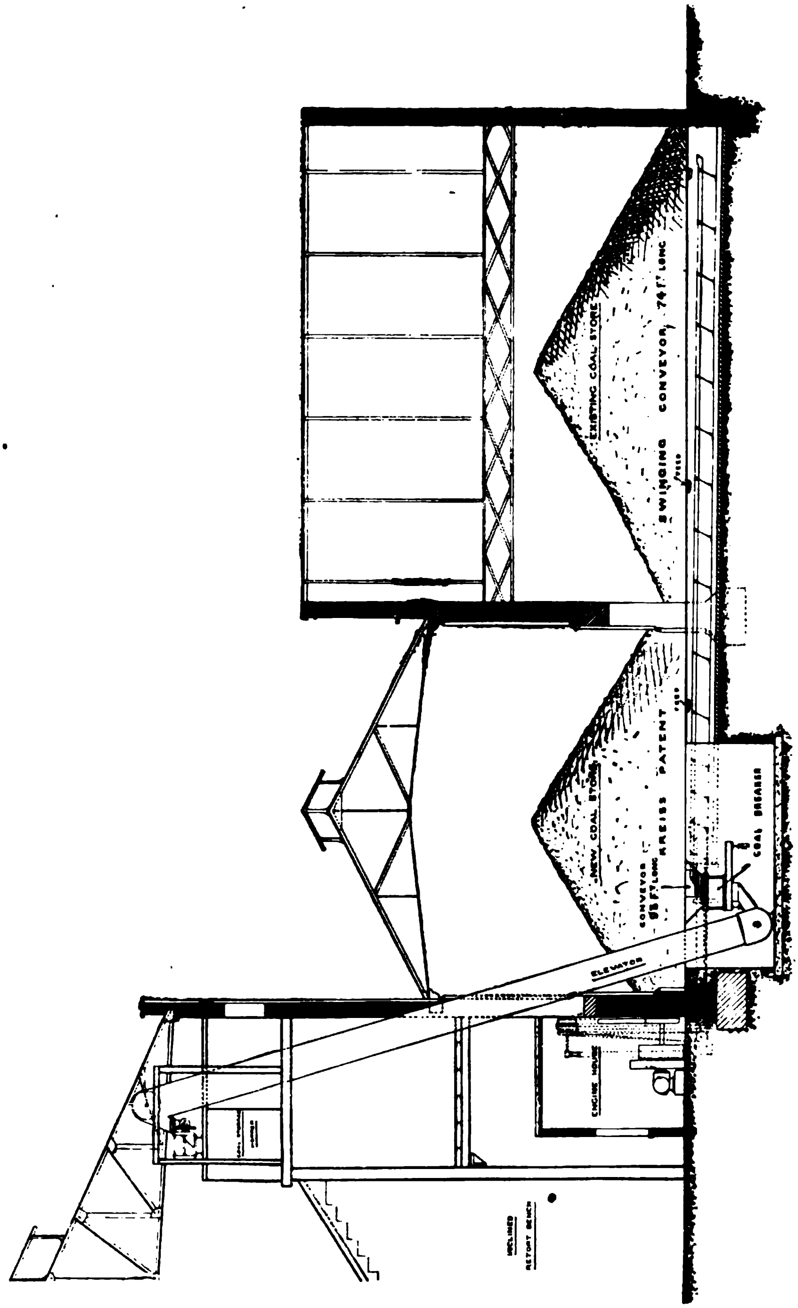


Fig. 153. Coal-handling Plant at Margate Gas-works.

immediately stopping the spray when the casting operations have ceased. Fig. 156A gives a good idea of the whole installation. It shows the engine-house with an

engine and an air compressor, as well as the necessary shafting to manipulate the three conveyors.

Fig. 153. Coke Conveyor at Margate Gas-works.

The moulds of the casting machines are clearly indicated on some of the large scale illustrations, which show the way in which the moulds so overlap each other as to prevent

spilling the molten metal. The moulds are ordinary Bessemer iron castings, and are provided with square recesses in the ends; square shank bolts fit into these, and connect them to the chain. The chain, which is a very important part of the apparatus, consists of steel links of 12-inch pitch, and is carried on chilled iron rollers.

The bushes on which these rollers run are made of 0·50 per cent. carbon seamless steel tubing, the spindles being 1 inch in diameter. The chutes which convey the red-hot pigs from the casting to the cooling conveyor are suspended from joists above, and are composed of steel bars 12 inches wide, so as to form a trough, the iron bars being held together by a 2½-inch round iron bar, and kept a short distance apart by pieces of pipe.

The cooling conveyor, which travels through a water tank, is provided with plates similar to a picking table. The chain itself is similar to that of casting conveyors, the

Fig. 156. Uehling Casting Machine and Conveyor at Millom Iron-works.

inside links in this case, however, having cast-iron brackets bolted to them, which in their turn carry ½-inch steel plates to support the pigs. These plates are 12 inches wide, the bolts fixing them to the casting being countersunk. At the delivery end, where the finished pigs are conveyed into railway waggons, there is a small cross conveyor and two discharging chutes which are of similar construction. These are suspended in very much the same manner as the chutes from the casting to the cooling conveyor, with the exception that the end of the chute is so held in position that the slant thereof can be easily altered.

The steam-engine has a cylinder 12 inches in diameter, and a stroke of 18 inches. It is coupled on either side to a 3½-inch steel shaft, which runs parallel to the conveyor. There are steel worms keyed to the ends of these shafts which engage with worm wheels of 33 teeth. The worms are 9 inches in diameter, on the pitch line, and have a 3-inch pitch.

[*To face page* 142.

The worm wheels are keyed to the countershafts of the casting machines. To these countershafts are also fixed friction clutches and sprocket wheels, the sprocket wheels driving the

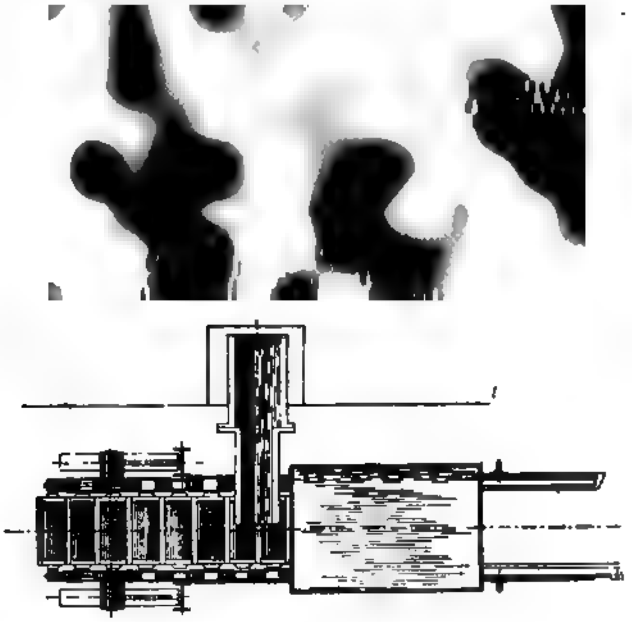


Fig. 157. Feed Terminal of Uehling Casting Machine.

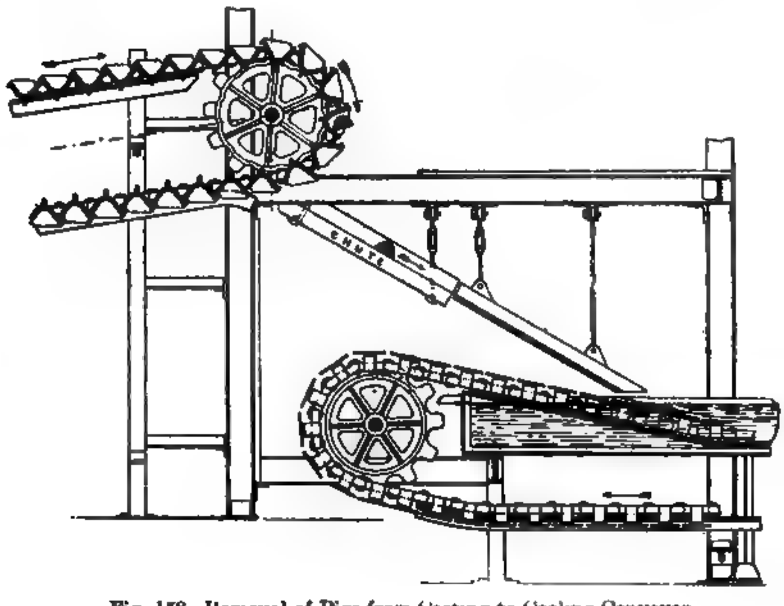


Fig. 158. Removal of Pigs from Casting to Cooling Conveyor.

chains which give motion to the casting machine proper. The sprocket wheel on the countershaft has 15 teeth, whilst the one on the casting machine has 45 teeth. The two

sprocket wheels driving the mould chains have 12 teeth and a 12-inch pitch. Only one of the sprockets at the pouring end of the machine is keyed to the shaft, the other one runs loose.

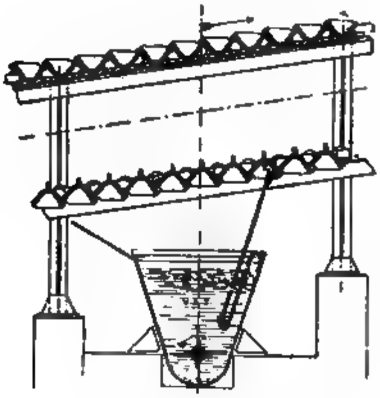


Fig. 159. Showing Method by which Moulds are Coated.

The paddle shaft in the spraying vat is driven by means of suitable sprocket wheels and a counter-shaft, as shown in the illustration.

The air compressor, which is also fixed in the engine-house, has a cylinder of 12 inches, and a stroke of 18 inches, the fly-wheels being 6 feet in diameter. The air compressor pumps into an air receiver 6 feet high by 2 feet 6 inches diameter (which is situated in the corner of the engine-house). This receiver is tested to a pressure of 120 lbs. to the inch, and is connected by suitable piping to the spraying vat. It is also fitted with the usual gauge and safety valve.

The capacity of this machine is 1,500 tons per day of twenty-four hours.

The "Heyl and Patterson" Casting Machine.—The first of these machines

Fig. 160. Heyl and Patterson Machine looking towards Delivery End.

erected in this country was, it is believed, installed by the Palmer Shipbuilding Iron Co., Jarrow-on-Tyne, and set to work in the beginning of 1899, at the Cambria Works.

This machine, which is here illustrated, has a capacity of 1,500 tons in twenty-four hours. It consists of a steel frame, combining a water tank with an upper and lower track upon which runs the chain carrying the pressed steel moulds into which the liquid pig iron is poured through the intervening runners. These are so arranged that the two or more rows of moulds can be fed simultaneously.

As before mentioned, the principal feature of this machine consists in this, that the pouring of the metal takes place into moulds whilst partly submerged in the water contained in the tank. The moulds travel in that condition for a sufficient length of time to allow the metal to solidify, after which they are quite submerged and travel through the tank to nearly the other end of the machine, at which point the chains run up a slight incline to the loading end.

Fig. 161. Arrangement of Discharging End of Heyl and Patterson Machine.

The moulds on their return journey pass over two furnaces in which crude oil or similar material is burning; and being still damp, readily receive a covering of soot which adheres to their interior and lips. The heat of the furnace also serves to so complete the drying of the moulds that they are ready for refilling.

Fig. 160 is a general view of the machine looking towards the delivery end, which shows clearly a portion of the moulds as they are partly submerged.

Fig. 161 is a view of the delivery end. The two strands of moulds are driven from one shaft by spur wheels, and are fitted with friction clutches so that either one strand or both may be used.

Fig. 162 represents two furnaces for drying and coating the moulds. These are mounted on wheels and can be withdrawn when the machine is out of work. The

moulds as they leave the water tank travel up an incline sufficiently high to give easy discharge for loading into railway waggons, each being fitted with a pair of runner wheels, 8 inches in diameter, similar to the machine previously described.

The chain consists of links of a 24-inch pitch which are joined together by pins

Fig. 162. Drying Furnaces for Moulds in Heyl and Patterson Casting Machine.

2 inches in diameter. The conveyor is not so long as in the "Uehling" machine, and the power consumed is 14 HP.

The "Ramsay" Casting Machine.—This machine was built for the Tennessee Iron and Railroad Co., Birmingham, Alaska, U.S.A., and varies considerably in form

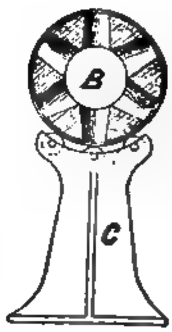


Fig 163. Filling Device of the "Ramsay" Casting Machine.

from those previously described, though the principle itself is very similar. The "Ramsay" machine consists of a girder of an annular shape, the sides being of sheet steel, and riveted together with angle irons. The intervening space is intercepted periodically by steel stays. This circular girder rests upon eighteen pairs of wheels,

the axles being supported by bearings bolted to the girder. The exact shape of the girder itself with its supports is shown in Fig. 163.

The moulds which receive the liquid metal are fitted with small trunnions which fit into a pair of bearings on the rims of the circular table. The inner periphery of the circular girder is fitted with toothed segments which form a complete circle for the

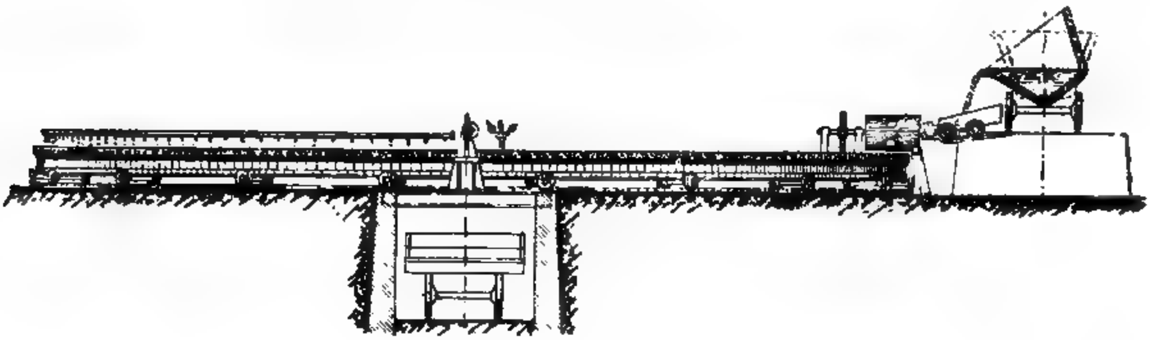


Fig. 164. Elevation of "Ramsay" Casting Machine

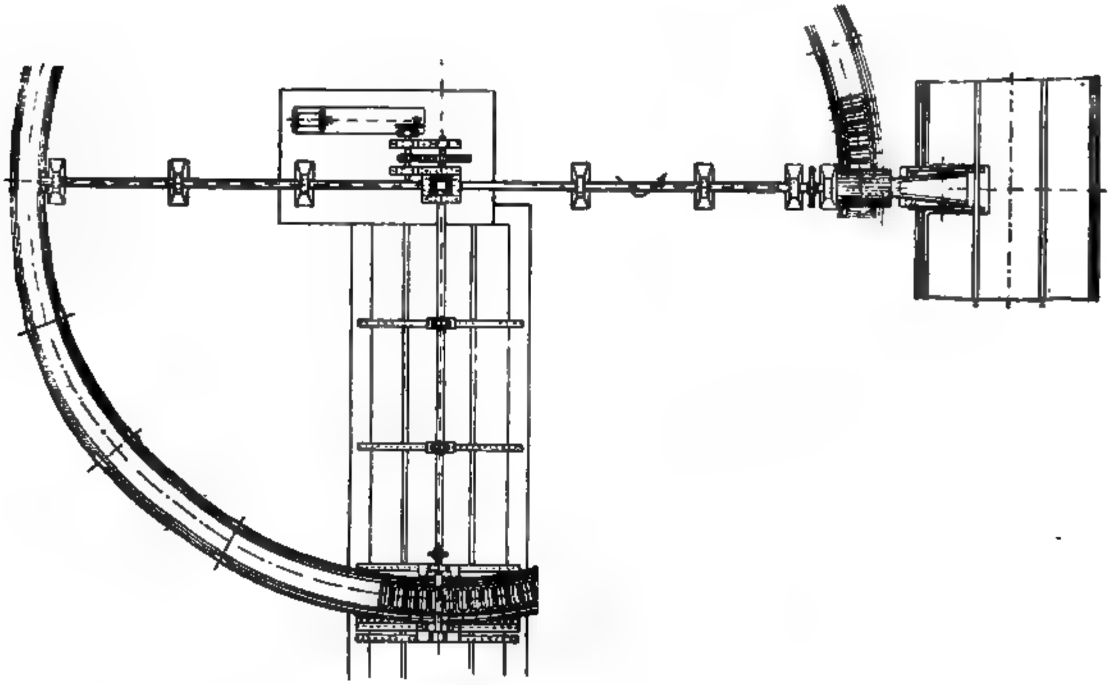


Fig. 165. Plan of "Ramsay" Casting Machine.

purpose of revolving the whole apparatus. The toothed segments which gear with the driving wheels are shown in a, Fig. 163.

Figs. 164 and 165 show the casting machine in plan and elevation. The plan also shows the engine coupled to three shafts, to the ends of which small spur pinions are keyed which cause the table to revolve in the direction of the arrow.

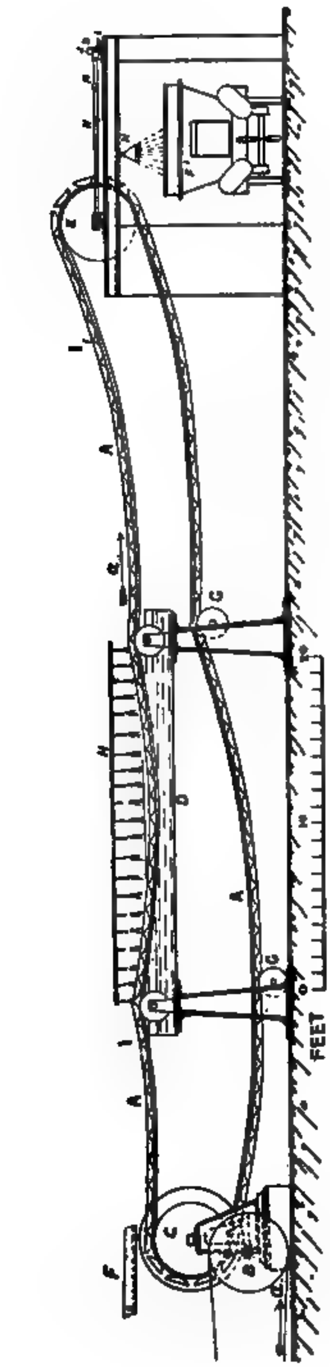


Fig. 166. Longitudinal Elevation of Hawdon's Slag Casting Machine.

Fig. 167. Plan and Elevation showing General Design of Hawdon's Pig-iron Casting Machine.

The filling device is shown in Fig. 163. The metal is poured first from a ladle into a chute A, by which it reaches the revolving filling drum B. The latter is driven by spur wheels, and the other side opposite to the drive is supported by three rollers fixed to the bracket C. Both A and B are lined inside with fireclay. The drum B has six radial apertures, and is caused to revolve at exactly the same circumferential speed as the moulds, so that the six exits are, so to speak, in pitch with the moulds, and the spilling of iron is thereby avoided, even if the moulds do not overlap each other, as is usual with most casting machines. The liquid metal in the moulds is cooled by sprays of water from a pipe which is shown in Fig. 164. The delivery point is shown in Fig. 168. A short length of tooth-rack *b* engages with the wheel keyed to one of the trunnions of each mould for the purpose of reversing it. At the moment of tilting, each mould receives a series of taps at the back from three hammers shown in the illustration.

Immediately behind the tipping device there is an appliance on the principle of an injector. This coats the interior of the moulds with lime water similar to the process employed in the "Uehling" machine.

The railway waggons in which the pigs are loaded are brought to the point of delivery through a cutting in the ground, as seen in Fig. 164.

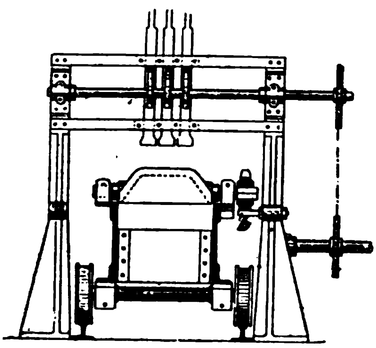


Fig. 168. Delivery Point of "Ramsay" Casting Machine.

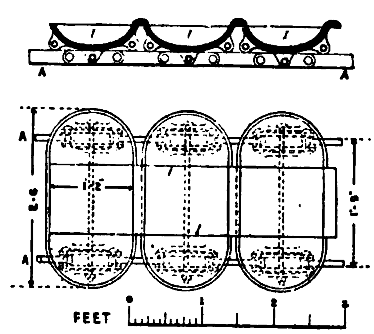


Fig. 169. Moulds of Hawdon's Casting Machine.

Hawdon's Slag Casting Machine.—Fig. 166 gives a longitudinal view of the machine. AA are two endless chains made of long steel links fastened together by pins or rivets. B is the driving shaft. C are the two pulleys over which the endless chains pass. These pulleys are driven from shaft B by geared wheels.

The moulds which carry the slag are shown in plan and cross section in Fig. 169 as fixed to the chains. It will be seen that they are bolted on to chain A by means of lugs on the under side.

The endless chains move in the direction of the arrow *a*. The slag is conveyed from the furnace by means of a trough F, whence it flows into the moulds which pass beneath it, then through the tank D, and on over the pulleys E. As the moulds pass over these pulleys the slag is tipped out in trucks, tip-waggons, or other suitable vehicles, and is further cooled by means of water sprinkled from pipe H fixed over the truck F^1.

To take up any wear in the chain, a worm and worm wheel are placed at JKL. These are connected by means of links MN to the spindle of the terminal E, and the attendant can at any time adjust the chain as required.

This machine was originally devised for the purpose of saving the labour which is

entailed in breaking up slag balls and wheeling them, by means of barrows, into hoppered barges for conveyance to sea, there to be tipped. But it is equally adaptable to cases where the slag is deposited on the ordinary slag-tip or mountain.

The saving of labour and of the wear and tear of plant as against the ordinary method of running into balls is claimed to be very considerable.

The slag thus made is very suitable for road-making, and especially for concrete, some thousands of tons having been sold for that purpose.

The "Hawdon" Casting Machine.—The machine illustrated in Fig. 167 is the design of Mr William Hawdon, who has for some years been connected with Sir B. Samuelson & Co.'s Newport Iron-works, Middlesbrough, and is a development of the casting machine for furnace slag previously described.

Fig. 170. Appliance for Loading Pigs from Hawdon's Casting Machine.

The general design of this pig-iron casting machine is much the same as that of the older type of slag machine, but it has been arranged more particularly for dealing with iron and also with a view to keeping the moulds dry on their return for refilling.

The moulds in the slag machine are dipped in water, while in the machine for iron they are to be kept dry. A secondary machine of circular shape is used for the cooling process. The pigs, when cool, are discharged from the circular conveyor, and ascend the elevator into railway waggons, as shown in the illustration.

The moulds attached to the chain are very similar to those previously described. On each one is cast a lip to prevent the flowing iron from falling between them as they pass in succession to the mouth of the tilting ladle.

Mr Hawdon has specially provided for the heavy weight to be carried. He has not attached the rollers to the moulds themselves, but has fixed them to the framework,

allowing the chain to run over the rollers, the bearings of which are at such a distance from the hot moulds as to allow of the free use of lubricant. Moreover, all the bearings are of brass, and are thoroughly lubricated.

The pulleys or rollers are placed at frequent intervals, thus preventing any unnecessary wear on the chains. This applies as much to the circular conveyor on which the pigs are cooled in a tank of water as to the straight conveyor in which they are cast.

It is important to notice that all the bearings in the circular conveyor are above water, and are therefore easily accéssible. With regard to the removal of the pigs from the circular conveyor to the waggons, it may be noted that, as they move round under water with the conveyor, they come in contact with a fixed plate or plough which pushes them off and into the elevator which delivers them on the waggons placed alongside.

Fig. 170 represents this elevator as used for loading the pigs from the cooling conveyor.

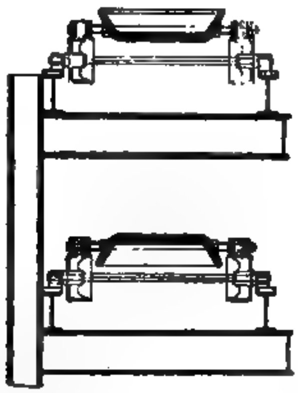


Fig. 171. Details of Moulds and Chains in Hawdon's Casting Machine.

Fig. 171 gives some of the details of the conveyor itself

The lettering given below describes the different parts of the machine: —

A. Moulds.
B. Chain carrying moulds.
C. Brass block fitted into chain to take the wear of the pin.
DD. Rollers carrying chain.
E. Brass bearings for roller shaft.
F. Spout to convey metal from ladle to moulds.
G. Shoot to convey pig moulds to cooling conveyor.
H. Table of circular conveyor or cooler.
J. Inclined plate or plough, which removes pigs from cooling conveyor to elevator.
K. Elevator which lifts pigs into trucks from cooling conveyor
L. Fixed bars between which the elevator works.
M. Rake of elevator.
N. Shoot.
P. Clutch for driving elevator.
R. Sprocket wheels.

INTERMITTENT HANDLING OF MATERIAL.

CHAPTER XV.

ENDLESS CHAIN AND ROPE HAULAGE.

APPLIANCES for conveying material intermittently consist, in their earliest form, of railways; but as far as this book is concerned, narrow-gauge railways only need be considered.

The motive force for these, apart from human power, may be obtained from the gravity of the material, from steam, or electricity, either direct or transmitted. Ropes or chains are used to propel these narrow-gauge trucks, but their own weight will suffice to propel them when there is a sufficient fall. The rails are raised on lofty structures where it is essential that the ground space should remain unobstructed, otherwise they are laid on the ground level. In the former case it is often better to use a single rail and suspend the trucks from this (aerial railway) in a similar manner to that in which skips are suspended from a ropeway, than to go to the expense of employing two rails for four-wheeled trucks. Iron rails are only used for the reception of trucks of this kind in cases where the rails can be supported at frequent intervals. If the supports must be

Fig. 172. Example of Chain Haulage for Colliery Tubs.

further apart, steel ropes are used to form the rail. Such methods of conveying the material are known as rope or cableways. The choice of the method of conveying must depend on the nature of the ground and the distance the material has to be conveyed.

Ordinary narrow-gauge railways are so well known as to need no particular description. Self-emptying trucks, which are sometimes used on such lines, have been dealt with elsewhere under the heading of "Self-emptying Railway Trucks" (see page 278).

Railways of this description running on steep inclines, in which the trucks are dragged up by ropes or chains, are principally used in collieries and other mines, and are often installed for the purpose of raising the trucks to a sufficient height to run them down a longer distance on a gentle incline.

Endless Chain and Rope Haulage.—Fig. 172 represents a colliery tub taken up an incline by means of a link chain with special attachments which engage with the axle of the tub and thus convey it up the incline. The chain is an endless one, and travels over two polygon terminals, one of which is fitted with tightening gear. There

are many similar devices; the one here illustrated is manufactured by Messrs Coulson & Co. Ltd., of Spennymoor.

Fig. 173 represents an appliance for the same purpose, in which the tubs are conveyed uphill by ropes or chains which engage with the top of the tub instead of with the axle as shown in the preceding drawing. It also shows the two terminals

Fig. 173. Example of Rope or Chain Haulage for Narrow-gauge Railways.

with the driving gear, and the tightening arrangement by means of a weight at the lower terminus.

This system is used not only in collieries but also in quarries and similar establishments. The chains or ropes engage automatically with the top of the tub as soon as it

Fig. 174. Rope Haulage Plant of the Röchling Iron and Steel Works, Völklingen, Saarbrücken.

comes within reach of them, but disengage as soon as the tubs have reached the higher level where they come without the reach of the chain. The empty tubs are returned on the second pair of rails and are lowered in a similar manner.

Although endless rope and chain haulage is mostly used for short distances, it must not be supposed that this system is not equally applicable to greater lengths. In the North of England and also on the Continent, endless ropes or chains are frequently used

for haulage over considerable distances. The difficulty about such installations lies chiefly in carrying the rope over uneven ground, the change of level of course necessitating a change in the direction of the rope, and also in deviations from the straight line, where sharp curves and abrupt angles have to be turned. In this system of rope haulage clips are fastened to the ropes or chains, which clips come in contact with and thus propel the tubs

As a typical example, the rope haulage plant erected by Georg Heckel, at the Röchling Iron and Steel Works at Völklingen, in the district of Saarbrücken, Germany, may be mentioned. The arrangement there is as follows: —

Fig. 175. Rope Clip used in connection with Colliery Tubs.

The railway commences in close proximity to the coal-washing plant (see Fig. 174), where the driving gear and the steam engine are also situated. There are two lines of rails, one of which is for loaded trucks and the other for empty ones on their return journey. The trucks or tubs are loaded from the bin A which receives the washed coal. When full, they are run on to the right-hand track of rails, and the rope is pushed into a fork-shaped clip attached to the front of each tub (see Fig. 175). By the traction of the rope the clip engages firmly as the fork turns on its axis and adjusts itself to the rope, and the truck is then carried along. The distance of travel is 264 feet, while the angles traversed are as much as 90 degrees, and the inclines

Fig. 176. Automatic Trucks in connection with Rope Haulage Plant.

as much as 10 degrees. After a sharp incline, the tubs turn round at the terminus B, and descend upon the second line. Before reaching the lower terminus the rope is so raised that it automatically disengages itself from the clips. The trucks discharge themselves automatically. Fig. 176 represents the tubs, the two sides *aa* being so hinged to the upper portion of the frame that the flap doors open outward. The bottom of the

tub is not level, but has a ridge in the middle sloping towards the flap doors, thus ensuring a complete discharge of the tub when these doors are opened.

Beneath the body of the truck is fitted a powerful spring which depresses the two levers *b*, and thus keeps the door closed. At the end of each of these levers *b* there is a latch which overlaps the side of the truck. Another lever *c* is fitted underneath the truck which carries at its end a roller running on the track. This is for the purpose of compressing the spring as soon as the rollers come in contact with an obstruction. By the compression of the spring the two levers which hold the sides of the truck are released, and thus allow the latter to open outwards. The unloading contrivance consists of a short inclined plane *d* made of flat iron, which is fitted in the middle between the lines of rails at the point where the trucks are to be unloaded, and in this way the discharge of the coal is effected at any of the three destinations.

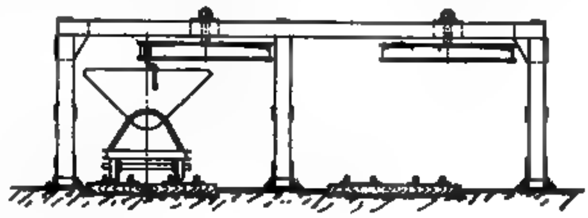


Fig. 177. Angle Station of Rope Haulage Plant.

The closing of the side doors of the trucks is also effected automatically. For this purpose immediately beyond each delivery point there are fitted on both sides of the track, rails *e* at the height of the lower edge of the movable sides *aa* of the truck, and at the ends of these rails are fitted two rollers with powerful springs. As the truck passes with open doors the rails *e* gently close the doors by pressing them behind the levers *b*.

In consequence of the sharp curves to be negotiated, the tubs are kept rather short, and the distance between the axles is such that it is not possible for the back wheels to be lifted off the rails by any pressure of the rope on the clip which is fitted to the front. The tubs are entirely of iron, and weigh over 13 cwts., having a capacity of about 17¾ cwts.

The rope is driven by a single cylinder steam engine, the cylinder having a diameter of 8 inches and a 12-inch stroke. The engine, connected by suitable gearing, works a double-grooved pulley, which in its turn drives the rope. The speed of the latter is 100 feet per minute. From this driving pulley the rope passes over two guide pulleys in a downward and upward direction. At the bottom of the loop thus formed is another guide pulley, which is weighted for the purpose of tightening the rope, which then passes to the commencement of the track, where there are two more guide pulleys, one of which guides the full rope while the other guides the return rope. With the exception of the wheels supporting the return strand, all the pulleys are grooved and lined with leather after Heckel's patent. The leather for these linings is stamped out in small pieces,

which stand on end and form grooves in the bottom of these rope pulleys. This arrangement has been found to effectually prevent any slipping of the rope.

The use of forked clips for engaging the trucks necessitates the rope running at all times at an equal distance above the line of rails. To ensure this at those points where the inclination of the track alters, special guide pulleys are used. These consist of a series of rollers fitted round the circumference of a revolving disc. The spaces between the rollers will accommodate the clips on the trucks. Vertical sheaves have been used, and the ropes are also guided in a lateral direction by a similar contrivance. In order to meet sharp curves in the track, channel irons have been used in place of the ordinary rails. These have been bent to the correct curve, and the sections are of such dimensions as to allow of but little play for the wheels in the groove (see Fig. 177). Special sections of rail are used to join up the channel iron to the rails, so as to gently guide the wheels from one section to another. Otherwise the illustration explains itself.

Fig. 178. Stops Built for Tubs Travelling in an Upward Direction.

To prevent interference with the traffic by a runaway tub which might become disengaged, there are placed upon the inclined portions of the track stops, built for trucks travelling uphill, as well as for those moving in a downhill direction. Figs. 178 and 179 represent these appliances.

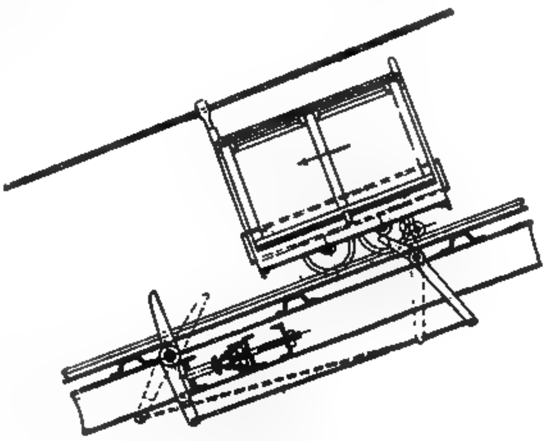


Fig. 179. Stop for Tubs Travelling in a Downward Direction.

The stop for tubs travelling in an upward direction consists of two levers which are fitted side by side in the track, and are coupled together by a horizontal axis round which they can rotate in the direction of the haulage. The axle is situated beneath the track, while the upright arms project above it (see illustration). In this position they are maintained by a weight. As the truck ascends the line, the axles of the wheels press the upright levers forward, and the truck passes over them without hindrance. Should, however, by some accident, the tub become detached, the levers catch and stop the descent because they do not admit of any backward movement. The shock to which the upright levers would be exposed under these circumstances is lessened by a powerful volute spring. The appliance for the descending

truck (Heckel's patent) is as follows:—At certain distances from each other two pairs of levers, similar in construction to those just described are fitted to the track. These levers are coupled together beneath the line so that both pairs must move together.

Fig. 179 shows the levers in both positions, one being in dotted and the other in full lines. It will be seen that the levers stand at a certain angle to each other. Their action is as follows:—As the truck descends, the axles of the wheels depress the short levers, and thus raise the longer and lower levers in an upright position standing at right angles to the track. As soon as the tub has left the first levers these will swing back to their original position, and thus pull down the long lever for the tub to pass over unhindered. Should, however, the tub descend at an unusual speed, as would be the case if a truck became disengaged, it would reach the lower levers before they had time to descend and thus stop the tub, the shock being again taken by a powerful volute spring. The distance between the two pairs of levers must always be accurately adjusted to the size of the tubs and their normal speed.

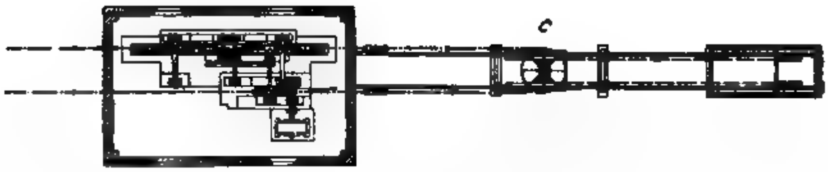


Fig. 180. Driving Gear for Rope Haulage Plant.

The driving gear of a similar installation built by Georg Heckel for the same firm is shown in Fig. 180. This plant is for handling 150 tons of iron ore per hour, but is capable of dealing with 300 to 360 tons. The driving gear is actuated by an electro-motor, and the rope pulleys are between 12 and 13 feet in diameter. The transmission from the motor to the rope wheels is effected by three pairs of spur wheels and three countershafts, thus reducing the speed of the motor to give the rope a travel of 200 feet per minute. After the rope (which is $\frac{7}{8}$ inch in diameter) has passed over the two main pulleys A and B, it is conducted over a horizontal pulley C, which is mounted on a carriage and connected with a weight which is suspended on a chain from a tower built for the purpose. This is necessary in order to take up the stretch of the rope, which is 32,800 feet long. The rope itself has a breaking strain of 29 tons, but it is only strained during the ordinary working to a load of 4 tons. The trucks are put on the lines at a pitch of about 35 to 40 yards. Each truck holds $1\frac{1}{2}$ tons of ore, and the highest incline on the line is 5 min.

CHAPTER XVI.

ROPEWAYS AND AERIAL CABLEWAYS, INCLUDING ROPEWAYS, CABLEWAYS, AND APPLIANCES FOR COALING AT SEA.

MODERN industry has made the widest use of ropeways (which are probably the oldest form of conveyor), as that method of handling material is termed which consists of drawing buckets or skips on ropes and by means of ropes, such buckets being filled with the material to be handled, and being automatically or otherwise discharged. In this chapter is given a succinct description of all the principal systems of rope and cable haulage, with some account of the various purposes to which ropeways and aerial cableways have been applied.

Ropeways may be divided into three sections—

1. *Ropeways proper, for conveying purposes only;*
2. *Cableways, which convey and hoist the material at the same time;* and
3. *Appliances for coaling at sea.*

1. **Ropeways.**—In the meantime it will not be uninteresting to explore the ancient history of the rope, as ropeways in some shape or form are almost as ancient as ropes themselves.

The late Sir Henry Layard, whose discoveries at Nineveh laid bare the daily life of the Assyrians, unearthed in a palace at Nimroud a bas-relief depicting the siege of a castle. In the carving the principal figure is that of a warrior, who is depicted cutting the rope to which the besieged had attached a bucket with which they were attempting to draw water from a well outside the castle wall. The rope ran through a pulley block. This bas-relief is about three thousand years old, and undoubtedly depicts a primitive form of rope haulage. Pulley blocks, which are also closely connected with ropeways, are, by the way, of considerable age. They were known to the ancient Egyptians, and in the museum at Leyden may be seen a sheave and pulley block of Egyptian origin, to which great antiquity is assigned. The sheave is of fir-wood and the block is of tamarisk. The rope found with these relics of an almost pre-historic past has also been preserved. It consists of strands twisted together out of the fibres of the date palm.

So far as is known, the ancients, though they made extensive use of fibre ropes, were apparently not much acquainted with wire ropes, which are of course an essential feature in the construction of modern ropeways. It is certain that the Assyrians practised the art of beating metal into wire, but whether they went so far as to make wire ropes or cables is not clear.

A fine specimen of bronze rope was, however, found in the buried city of Pompeii, and is now preserved in the Museo Borbonico, Naples.

Unfortunately no information seems to be available as to the purpose to which this wire rope was applied, but its discovery in buried Pompeii is significant in view of the very modern date that has been claimed for wire ropes.

The origin of ropeways is, like that of many other flourishing institutions, lost in

the mists of antiquity; but it seems quite possible that this means of transporting material was practised by the ancients, who had made more progress in engineering than is often credited. It may be objected that no traces remain of these ropeways, if ever they existed. It must be borne in mind, however, that then, as now, ropeways were often essentially transitory works, erected for special purposes, and bound to disappear as soon as the needs that called them into existence had passed away. Moreover, ropes are not objects that are calculated to defy the effects of time.

A curious old print (see Fig. 181) gives a graphic delineation of a ropeway that was erected by a Dutch engineer, Adam Wybe, of Harlingen, for the city of Dantzig in 1644.

Fig. 181. An Early Ropeway erected for the City of Dantzig.

This ropeway connected the city ramparts with a hill outside the town known as the Bischoffsberg. A single rope was passed over pulleys suspended on high posts, two of which were embedded in the city moat. The rope carried a number of rather diminutive buckets which were filled with earth on the hill and were discharged at a certain point on the ramparts. Probably the earth was used for strengthening the fortifications. The empty buckets were returned to the starting point on the same rope, which ran back on another line of posts. This was simply an endless rope running between two not very distant points.

The modern ropeway may be said to date from the adoption of wire ropes and cables. It is a remarkable fact that, although, as already stated, wire ropes were known to the

Romans eighteen centuries ago, they were not pressed into the service of modern engineering till the nineteenth century was well advanced.

The practical use of twisted wire rope seems of no earlier date than the thirties; though wire ropes were reported to have been used in England as early as 1832, the pioneer in this field is believed to have been a German engineer, Professor Albert of Clausthal, who introduced these wire cables into his native land in 1834.

The first English patent for ropeways was taken out on the 20th of July 1868, by Charles Hodgson, on whose invention most of the modern ropeways are more or less founded.

As far as the author has been able to ascertain, the first ropeway of any note erected on the single rope system was built in the year 1860, in the Hartz Mountains, by Baron von Dücker. The first ropeway on the double rope system, that is to say, with hauling rope and rail rope, was also built by him between the years 1868 and 1870.

Ropeways may broadly be divided into single and double systems, these again being capable of subdivision. The simplest form of ropeway is that already mentioned as having been erected for the city of Dantzig in the middle of the seventeenth century. In this primitive type the load to be carried is conveyed by a single endless rope which runs from one point to another. This class of ropeway, unless great attention is paid to its details, is not suitable for any but comparatively light work, and cannot therefore be erected unless the points to be served are at no great distance apart.

In the double ropeway, which is the most generally diffused type in these days, the load is carried on a fixed rope, which serves much the same function as a railway, except of course that the railway rests on sleepers, while the rope is carried through the air. This rope is fixed and taut, whilst the load is drawn by the second rope, which is called the hauler. These are the broad outlines of ropeways, but the following subdivisions may be made.

There is first the *endless running rope* from which the carriers are suspended, and with which they move by frictional contact. A modification of this type is the *single endless rope*, to which the carriers are fixed, and with which they move as the rope moves.

A distinct type is the *single fixed rope*, on which the carrier runs, being drawn to and fro by means of an endless moving rope which acts as a hauler; or again, *two fixed ropes* may be served by the endless hauling rope. Here one carrier will travel in one direction while the other will run on parallel lines in another direction. Before proceeding to consider the various conditions under which these different types of ropeways can most advantageously be used, it may be as well to summarise the advantages of ropeways as a means of conveying heavy material over varying distances.

First of all, it may be stated that the prime cost and working expenses of ropeways are relatively moderate. Of course, the manufacturer who would put up a ropeway should estimate exactly what work it will have to do, so as to proportion his outlay to the useful effect he desires. The working expenses should be moderate, as even extensive ropeways require but a small working staff. The cost of repairs and upkeep must necessarily be considered, but good material and sound workmanship will, in this as in other cases, reduce expenses to a minimum. One great advantage of a ropeway is this, that it may be worked over ground that would be impracticable for a tram or railway, except at a prohibitive cost. A practicable ropeway may often be erected where otherwise costly bridges would have to be built. It is further contended that ropeways are independent of weather conditions, and this is no doubt true to a certain extent, because in a mountainous country a heavy fall of snow, which would stop the working of a tramway, would rarely interfere with the working of a ropeway. But it is a question

if the best constructed ropeway can always be worked in high winds and gales, though on this point experts differ. It is usual, however, to protect dwellings and thoroughfares over which ropeways pass by guards or safety nets.

* Ropeways have undoubtedly the advantage of simplicity of construction, and should not under ordinary conditions be subjected to interruptions from the gear getting out of order, though of course ordinary care must be exercised by the staff, which, as already observed, need not be extensive. Skilled labour again should not be required in connection with a ropeway. Beyond one competent engineer to superintend the working of the line, unskilled labour should suffice. The power required to drive ropeways is relatively small, and under some conditions no driving power at all is required. The ropeway has also the advantage of portability in this sense, that the supports on which the line rests can be taken down and the entire ropeway removed to another district when its services are no longer required in its original position. In many cases, however, the ropeway erector must take into consideration the capital that may be absorbed by "wayleaves," because unless the ropeway is run entirely over his own ground he will be compelled to come to some arrangement with the proprietors of the land over which the ropeway will pass. This is termed a "wayleave."

It is understood that on the Continent landowners are not generally over exacting with regard to "wayleaves," but in this country the reverse seems to be the case. More than one ropeway which might have rendered good service has been abandoned because of the excessive value placed by landowners on the "wayleaves" they were asked to grant. Yet the ropeway has this advantage, that it interferes little, if at all, with the land over which it passes. The amount of ground required for the supports is so trifling as to be practically a negligible quantity, while the line itself in no way interferes with the cultivation of the ground underneath.

Ropeways, however, have their limits; and although they can be carried over the most difficult ground if in straight lines, curves considerably increase their expense and working cost, necessitating as they do the erection of angle stations. The modern ropeway dates little more than a quarter of a century back, but during this period the distances which can be traversed and the loads which can be carried have undergone remarkable developments.

Lines have been constructed on the "Otto" system varying from 10 to nearly 20 miles. The exact form of ropeway which it may be found desirable to adopt will no doubt vary widely with the nature of the ground and of the work required to be done. In the same way details of construction, such as the kind of material for the supports, will depend more or less on local conditions. In one case wooden supports may be found quite sufficient, while in others iron may be preferable. Generally speaking, it may be said that the simplest form of ropeway, the *single endless running rope*, with carriers moved by frictional contact, is more suitable for short distances and moderate weights. The inclines should not exceed 1 to 3, nor the individual loads 5 to 6 cwts. Spans of great length are to be avoided, unless on very broken ground, or over deep valleys, where a span of considerable length is unavoidable. Such a ropeway would be arranged as follows:—At one end a driving drum, varying from 5 to 10 feet in diameter, would be provided with the necessary gear for receiving and transmitting the power, while at the opposite terminal a similar wheel would be provided with tightening gear. The endless band of wire rope would run round these two wheels, the said rope being carried between

* The author is indebted to Mr W. T. H. Carrington, M.I.C.E., for portions of the following description.

the drums on suitable pulleys, the diameters of which would vary according to the size of the rope. These pulleys would be carried on posts or supports of iron or timber. Further, such supports would be placed about 200 to 300 feet apart, at a sufficient height to enable the carriers (as the skip or other receptacle in which the material is conveyed is termed) to clear all obstacles. These carriers hang from the rope and pass supporting pulleys by means of a curved hanger, pivoting in the Λ-shaped saddle which rests on the rope, and attached at its lower end to the skip by means of a hook. The saddle is an iron frame, fitted with friction blocks of wood, rubber, or composition, causing sufficient adherence to the rope and enabling the carrier to pass with the rope up steep inclines and over the pulleys. The frame carrying these friction blocks is usually made of malleable cast iron, and is provided with wings at each end which, as the carrier arrives at the supporting pulley, embrace the pulley rim and pass over it. The frame which carries these friction pieces is fitted with two small wheels, carried on wheels attached to it, which are known as shunt wheels. Their function is to remove the carrier from the rope at terminals or curves, where shunt rails are placed. These rails are held in such a position that when the carrier approaches the terminal the small wheels engage on it, and running up a slight incline, lift the saddle from the rope, enabling it to pass to where the loading or unloading is required to be done, or round the curve wheels. The impetus derived from the speed of the rope (which averages 4 miles an hour) is sufficient to enable the carrier to automatically clear itself from the rope. This form of ropeway consists, therefore, of one endless wire rope driven by suitable gearing, and supporting carriers which travel with it either by means of friction or mechanical clips. One of the lines erected on this system in this country extends to a distance of 1½ miles, and carries 200 tons per day of twelve hours.

A modification of this form of ropeway is one in which the carriers hang from and move with a single rope, being rigidly fixed on it. This system is recommended for routes on which steep inclines and sudden changes of level occur. As guide or depressing pulleys may be placed wherever necessary without obstructing the passage of the carriers, the vertical angle of the line may be changed at each support. Although this form of ropeway is similar in all such respects as driving and tightening gear and pulleys to the first-mentioned system, there is this important difference, that the carrier does not rest on the rope, but is clipped to it by a steel band which embraces it, being tightened by a suitable arrangement. As the carriers are fixed, they obviously must move with the rope, and, owing to the arrangement of the terminals, they will necessarily pass round the terminal wheels.

The driving wheel is usually in the form of a special clip drum, and the terminal wheel, where the tightening takes place, is so arranged that the passing of the carriers can be easily effected. When it is desired to unload, the carrier is allowed to strike a catch which causes the bucket to capsize or to open at the bottom.

Loading, which is a more delicate operation, can be effected by a variety of devices, all more or less ingenious and efficient. Thus a carrier can be loaded either while passing the driving drum, or at a point adjacent thereto, for instance by means of hoppers or cages moving at the same speed as the carrier and operated by it; or again, the ropeway may be run at the slow speed of 2 to 2½ miles per hour, in which case the carriers can be loaded or discharged on passing the terminals by hand labour. An interesting example of this kind of ropeway is mentioned by Mr Carrington as having been erected in Ceylon on a tea plantation. This has a length of about 3 miles, and passes over several steep ridges. The leaf (in bags) is placed in the carriers (which are in the form of cages), as they pass the driving terminal. This driving terminal is operated

by wire rope transmission communicating the power required from a turbine $\frac{3}{4}$ mile away. The ground is so broken as to necessitate the use of several guard wheels, the function of which is to depress the rope; as the load passes, its weight relieves the pressure on the guard wheels, and enables it to pass under the guard wheel, which again performs the office of depressing the rope. In this case the loads on arriving at the tightening and discharging terminal are lifted by hand off the carrier, but a simple automatic arrangement can be provided, by means of which a projecting bar is allowed to strike the carriers, whereupon the bags are delivered automatically.

An example of a *double ropeway* is one in which the carriers are drawn along a fixed rope, by a trailer which acts as a rail, and return on a parallel fixed rope. This kind of ropeway is applicable in cases where the loads to be transported exceed 400 tons per day; where individual loads exceed 6 cwts.; where the incline exceeds 1 in 3, and where long spans are necessary. A ropeway of this type would be erected as follows:—

Two fixed ropes are stretched parallel to one another, about 7 feet apart, and supported by posts, fitted with saddles, at a distance of about 300 feet from one another. The ropes are anchored at one of the terminals and tightened at the other by suitable gear. The carriers run on the fixed ropes as on a rail, and are fitted with running heads carrying steel grooved wheels. The hanger from which the load is suspended is pivoted from the carrier, and the load is conveyed at a speed of 4 to 6 miles per hour by an endless hauling rope operated by suitable driving gear at one end, and controlled by tightening gear at the other. The hauling rope is attached to the carrier by an automatic clip which will release itself by touching a bar on arriving at the terminal station, but will hold sufficiently tight to enable the hauling rope to drag the carrier up inclines. The hold of the hauling rope on the load may be supplemented by knots or sleeves on the former, or by means of a suitable casting inside the rope at certain points, so as to make an enlargement at the point where the clip engages. It has been objected to these devices that they are apt to occasion undue wear. An excellent method is that in which the hauling rope is held by a clip simply by pressure resulting from the operation of wedges acting on inclined surfaces or screws. With slight inclines the pressure of two pulleys or plane surfaces on each side of the hauling rope is sufficient, but in the case of sharp inclines where the pressure on the hauling rope is severe, the clip attached by means of wedges may be used. With lines erected on this system shunt rails and driving and tightening gears are used, just as in the single rope lines. At each of the supports rollers have to be provided on which the hauling rope rests when it sags between the carriers.

These rollers are provided with guide bars to increase the range of support, and guide the hauling rope, should it be deflected from the vertical, into the above-named pulleys.

A line on this system, of about 1,800 yards in length, is at work in Japan, running mostly at an incline of 1 in $1\frac{1}{2}$. It is used to carry ore from the upper terminal to the lower. Such is the power generated by the descending loads, that it has been found necessary to absorb the greater part of it, so as to render the line amenable to the control of a hand brake. With this view a hydraulic brake was introduced in which the revolving fan drives the water against fixed vanes which again repel it. By this means about 50 HP. was absorbed and the speed regulated to a nicety by adjusting reaction vanes against which the water impinges.

A variation of this system is that of a *single fixed rope*, on which one carrier, hanging from the fixed rope, is drawn to and fro by an endless hauling rope. This kind of ropeway has been found useful under conditions where moderate quantities have to be transported in heavy loads or pieces, or where spans of considerable length have to

be worked over. Inclines up to 1 in 1 can be worked and a span up to 2,000 yards used, while loads up to 5 tons may be carried. The endless hauling rope is operated by any available power, the driving gear being arranged with reversing motion so that the direction in which the carrier runs may be changed as required by the attendant. The fixed rope is supported on posts spaced at intervals of 300 feet, while the hauling rope is carried on pulleys fitted with guide bars and placed in the centre of the post over which the carrier passes, the posts of course being so arranged as to allow of the carrier clearing them. The return hauling rope may be supported on an outside pulley mounted on an arm of each post. The hauling rope is attached to the carrier head by suitably placing a pendant which causes it to pass under the saddle transom.

A ropeway erected on this system by Messrs Bullivant is at work on Table Mountain, at the Cape of Good Hope, and has a length of 5,280 feet. This line commences at the sea level, and following the ground on posts spaced about 300 feet apart, takes a span of 1,500 feet, rising to a projecting rock 1,480 feet above the starting point. Resting upon this support at this point, it again makes a span of 1,400 feet to an upper terminal 62,200 feet above the lower one.

An interesting example of this kind of ropeway may be found at Hong Kong, where it is used in connection with a sugar factory, for conveying the staff to and from the works. In this factory are employed a number of European workmen, who are lodged, on account of the fever-breeding nature of the lower ground, in a sanatorium built at a high level above the sea. The carrier will accommodate six men at a time, and is run at a speed of 8 miles an hour. The men, leaving their work in batches, find the carrier at the terminal prepared to take them up to the sanatorium. This ropeway is said to have been at work for several years without a single accident. In a general way, however, ropeways are not used for the carriage of human loads, though it is quite conceivable that in wild countries such means of conveyance might be found highly practical in connecting the edges of steep ravines, and thus avoiding the construction of more expensive bridges.

Another type of ropeway is that which consists of two *fixed ropes* with an endless hauling rope, in which one carrier will run in one direction while the other runs on a parallel rope in an opposite direction. Such a ropeway can be used over long spans where individual loads amounting to 5 tons have to be transported. It would be suitable in cases where the ropeway could be worked by gravity, the descending load moving by its own weight, while the empty carrier ascends unloaded. In such cases spans of 2,000 yards may be used, and loads of 6 tons carried.

It is clear then that ropeways may be divided into two grand divisions, namely, single and double ropeways. In the first case the load to be moved is carried by an endless rope forming the ropeway. In the second the load is suspended from a runner drawn along the fixed rope by a separate traction rope commonly known as the hauler.

The subdivisions of these two main types as mentioned are many, but are due, as already explained, to diverse conditions as regards ground, and the load under which the ropeways have to work. There is no doubt that in planning a ropeway particular attention must be paid to the ground, as well as to the loads that are to be carried.

Mr J. Pearce Roe, an engineer who has devoted much attention to the construction of ropeways, has well observed that in dealing with rough or mountainous ground the methods of ropeway and railway engineers are diametrically opposed, for whereas the one in laying out the line seeks easy grades so as to avoid, as far as possible, irregularities, the other ignores, as a rule, the conditions of the ground, and follows a bee-line from point to point.

Up and down gradients which balance each other may be ignored, and the driving power arrived at by taking the mean gradient between the terminal points.

In cases where the mean gradient is in favour of the load, the ropeway will become self-acting, and under certain conditions may even develop surplus energy. The ideal ropeway should go straight from point to point, the rope being supported wherever the ground lends itself to the erection of standards, which should, however, not be raised higher than necessary. With regard to the altitude of standards, however, the engineer is necessarily limited by the ground. It may be noted that since so many engineers of eminence devoted themselves to the construction of ropeways, great improvements have been made in the details of construction, and in particular that the high trestles which were so marked a feature of the earlier ropeways have to a great extent been suppressed. It is probable, too, that the power used in working ropeways has been very considerably reduced by the selection of gradients in favour of the load. Those who have erected ropeways in different parts of the world have claimed that in dealing with rough and mountainous lands great economy has been effected in the mere length of the line laid as compared with that a tram or railway would require. For instance, the case has been cited of a ropeway of a length of some 5,400 feet, and a difference in altitude of

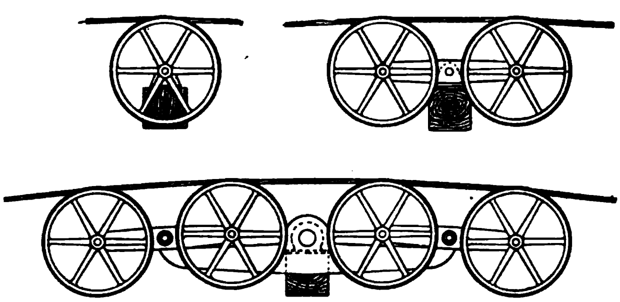


Fig. 182. Grouped Sheave Mountings with Balance Beams.

over 2,000 feet. This ground if covered by a railway would require a length of about 15 miles of rails graded at 1 in 40.

The cost of transport by ropeways must vary necessarily with the conditions, but generally speaking the working expenses of a ropeway compare favourably with those of a railway. On some well-planned and well-laid ropeways the wear and tear of the ropes, which is actually the largest item of expense, is said to be between $\frac{1}{8}$d. and $\frac{1}{4}$d. per ton per mile. Broadly speaking, the cost of handling must vary with the natural obstacles on the route and the quantities to be carried.

An example which may be mentioned to show the wear and tear of rail ropes is that of a ropeway erected by Messrs Bullivant & Co. Ltd. in Spain, which was employed to convey loads of from 300 to 350 tons per day a distance of 1 mile between Badovalle and Ortuella, so that it is estimated that one rope carried over 160,000 tons. As the ropeway was at work incessantly from July 1893 to July 1895, the cost of rope renewal meant an expenditure of $\frac{1}{4}$d. per ton per mile. The rope when new had a breaking strain of $29\frac{1}{20}$ tons, and the test showed that the disused rope had still a breaking strain of $27\frac{1}{2}$ tons.

Roe's System of Aerial Ropeways.—Mr Roe, of the Ropeways Syndicate,* has described one of their light ropeways, measuring some 4,000 yards, erected in Japan,

* Now "Ropeways Limited."

which is carried over very rough and broken ground, and yet is only supported by seventeen trestles, each trestle being placed on as high ground as practicable, so that no one support is of any considerable height. The rope is carried over a ridge 1,520 feet at the crest, above the discharging station. In this line an altitude was attained of 1,130 feet in a distance of 1,200 yards.

In this instance the contour of the ground lends itself to some long spans, two at

Fig. 183. Quadruple Balanced Beam and Sheaves.

least clearing distances of about 2,000 feet. This ropeway has a daily carrying capacity of 60 tons in one direction and 30 tons in the other.

One of the largest installations yet erected on this system is that of the Bacares Iron Co.'s Mines, Seron, Spain, which was designed to deal with 70 tons per hour.

This ropeway covers a distance of 6,500 yards, and is over very rough ground—so rough, indeed, that in places the road is inaccessible even to mules, and the material for the erection had to be carried on men's backs. It may be added that this ropeway has in actual work dealt with 85 tons per hour, showing a margin of over 20 per cent. on its carrying capacity.

The large capacity obtainable from a single ropeway working on the Roe system may be seen from this example.

The greatest length worked in one continuous section by this system is the ropeway

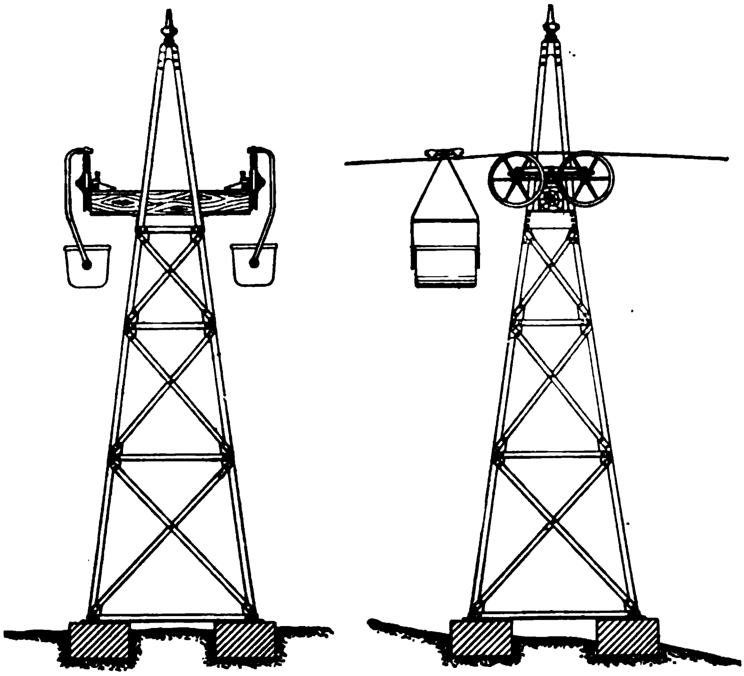


Fig. 184. Elevation of Steel Trestle with Pair Balanced Sheaves.

erected for "Pure Salt Ltd.," situated at Remolinos, near Zaragossa, Spain, which is 7,100 yards in length, and has a carrying capacity of 35 tons per hour.

The attention of the Ropeways Syndicate has chiefly been confined to the design and construction of single rope installations, they being the first to introduce multiple sheaves for supporting the rope, which greatly facilitates the working of long spans, and reduces the wear and tear and friction on a rope to a minimum.

Illustrations of their single, pair, and quadruple balanced beams and sheaves are shown in Figs. 182 and 183.

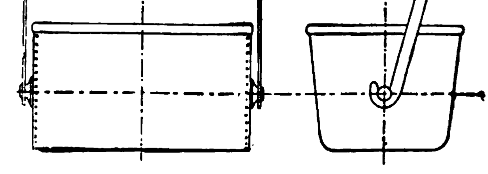


Fig. 185. Ordinary Bucket for Ore, Coal, &c.

Grouping sheaves in this manner simplifies the construction of ropeways and enables long spans to be worked without undue pressure on the supporting sheaves, as the balanced beams allow the sheaves to adjust themselves and follow the angle caused by the rope passing over them, so that by this means the pressure is equally divided all the time on every sheave.

Fig. 184 shows an example of trestle fitted with a pair balance beam and sheaves.

Figs. 185, 186, and 187 illustrate a few forms of carriers used for different purposes.

Fig. 188 shows plan and elevation of unloading and tension station built on the single rope system by the above-named firm.

Figs. 189 and 190 give examples of Roe's unloading stations, Fig. 189 being

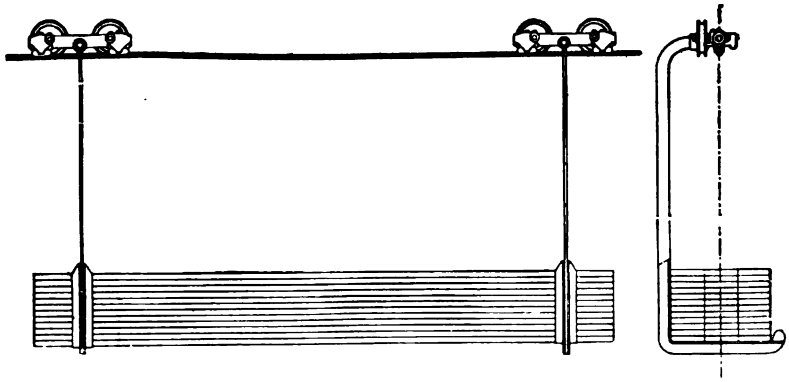


Fig. 186. Carrier for Timber.

a terminal for driving by power, whilst Fig. 190 represents a loading terminal for a gravity driven line, showing band brake. These brake stations are also fitted with hydraulic resistance regulators to automatically govern the speed of the ropeway.

Fig. 191 shows a view of the loading station of the ropeway erected by the Ropeways Syndicate for the Wentwood Water-works, Newport, Monmouthshire.

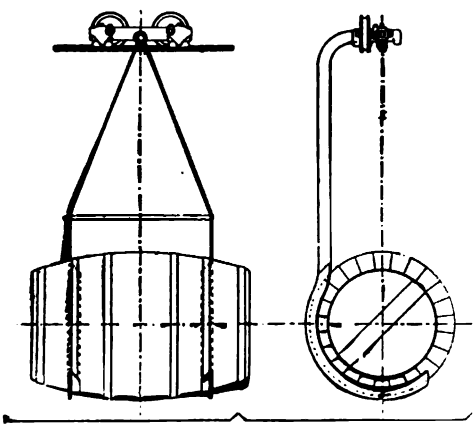


Fig. 187. Carriers for Barrels, Sacks, &c.

It is for the purpose of conveying clay, and has a capacity of 240 tons per day of ten hours. The line is 3½ miles in length.

Fig. 192 represents an angle station. This is at a point where the ropeway diverges slightly from a straight line. It is in use on the Mazapil Copper Co.'s ropeway in Mexico, which ropeway has a capacity of 250 tons per day of ten hours. This installation, as well as the three following, was built by the Ropeways Syndicate.

Fig. 193 represents a view of the line erected for the Cork Brick-works, Ballanhissig. The capacity is 140 tons per day of ten hours, and the length of the line is 4 miles.

The peculiar shape of the carriers has been adopted for the purpose of carrying bricks.

Fig. 194 represents a view of the line erected for Messrs Borner & Co.'s Iron Ore Mines at Almeria, Spain; it has a capacity of 250 tons per day of ten hours.

Fig. 195 represents the unloading station of the ropeway for Messrs Newall & Co.'s granite quarries at Dalbeattie, Dumfries. Capacity of line, 250 tons per day of ten hours.

ROPEWAYS ERECTED BY MESSRS BULLIVANT & CO.

Ropeway at the New Beachy Head Lighthouse.—In consequence of recent serious encroachments of the sea in the locality of Beachy Head, the Corporation of the Trinity

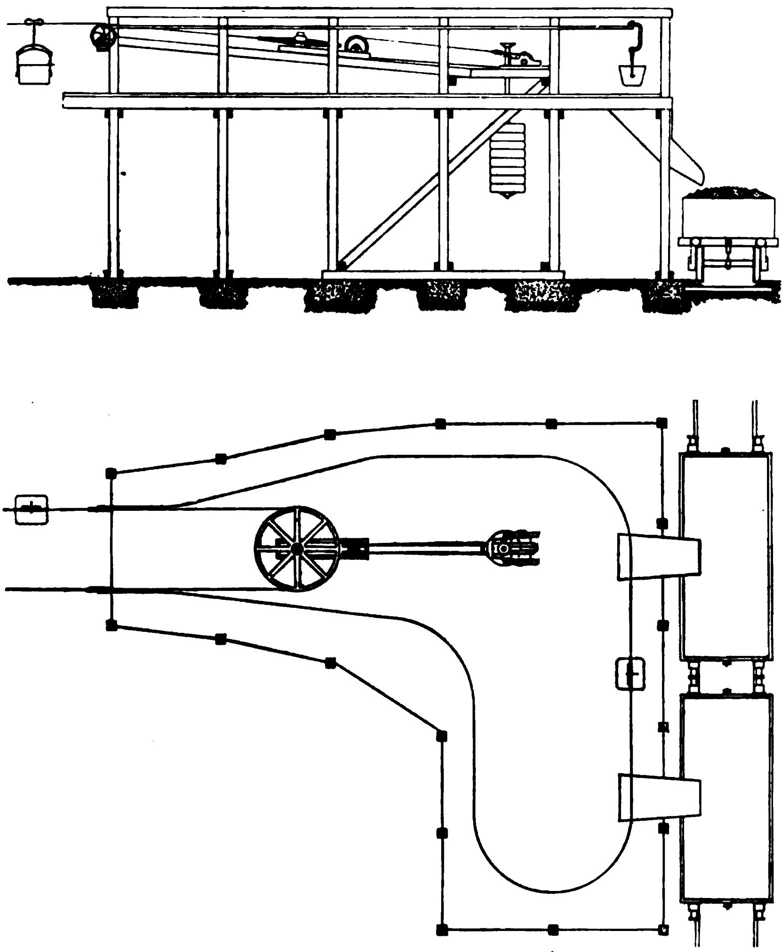


Fig. 188. Plan and Elevation of Tension and Discharging Station.

House decided in 1899 to abandon the well-known lighthouse on that promontory and erect another structure on the foreshore beneath.

It having been deemed desirable to establish the workyard at the top of the cliff at a height of about 400 feet above the sea, it became necessary to construct a ropeway of a special character for the purpose of carrying loads to a staging erected a little below low-water line on the shore at the site of the proposed lighthouse, which lay about 600 feet from the base of the cliff (see Fig. 196).

Mr W. T. H. Carrington, M.I.C.E., the consulting engineer to Messrs Bullivant & Co. Ltd., having in consultation with Mr Matthews prepared the necessary designs for the ropeway, the construction of the latter was entrusted to that firm. The chief work the ropeway was required to perform was to transport blocks of granite weighing about 4 tons each for the construction of the lighthouse; but it had also to transport the machinery needed in the building, such as pumps, steam engines, cranes, &c., as well

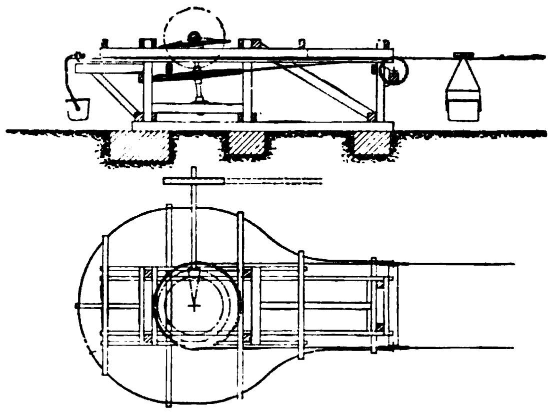


Fig. 189. Plan and Elevation of Driving Terminal.

as all the cement, shingle, &c. In addition to this it was also necessary that the ropeway should provide a convenient means for the conveyance of the workmen down to and up from their work on the lighthouse (see Figs. 197 and 198).

From the illustrations it will be seen that the descending load draws the ascending

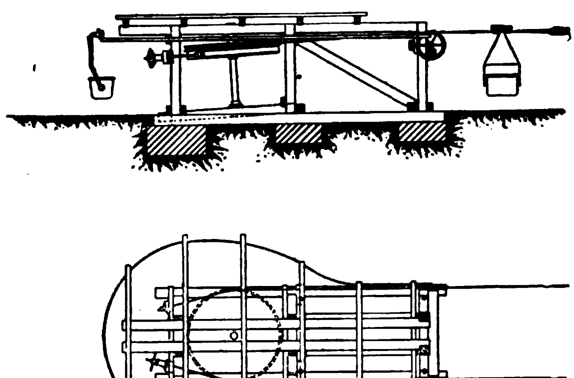


Fig. 190. Plan and Elevation of Brake Terminal.

load up. This arrangement is necessarily modified in order to provide for bringing up workmen when no materials are ready to send down. A small auxiliary steam engine is therefore provided.

The arrangement of the plant is as follows:—Two fixed ropes—one 6 inches in circumference with 120 tons breaking strain, and the other $5\frac{1}{2}$ inches in circumference with 100 tons breaking strain—are stretched parallel to each other between the termini.

These ropes terminate at the upper end at a massive wooden trestle carrying tension bars fitted with thimbles suitably supported in brackets on its summit, to the outer thimbles of which the above-named fixed ropes are attached, the strain being transmitted

Fig. 191. Loading Station of the Ropeway of the Wentwood Water-works.

through the tension bars to tie-backs which are attached in the rear, transmitting the strain to the anchorage further in the rear. Thus the fixed ropes, at the point where the strain is most severe, are not subjected to any bending action.

At the lower terminal it is necessary to transmit their strain to an anchorage in

the rear of the staging, since the staging itself is not constructed to safely take any side strain. The lower ends of the fixed ropes are therefore attached to double screw tightening gears, which in their turn form the end of the back tie-bars. These are

Fig. 192. Angle Station of the Ropeway of the Mazapil Copper Co.

made of steel bars connected by pins, terminating in anchor bars which are buried in the chalk in the bottom of the sea some distance in the rear of the staging, concrete being filled up round them and placed over them in such a quantity as to resist the pull.

The tightening is accomplished by an arrangement of two screws, combined so that when the tightening is effected by one screw, the other acts as a fulcrum and reduces by one half the strain necessary to apply on the screw for tightening. This tightening gear, with a drift of about 8 feet, is carried on a strong wooden frame placed on the staging above referred to, and advantage is also taken of this frame to carry suitable lead-on pulleys and a wheel, round which the return hauling rope passes.

Fig. 193. View of Support of the Ropeway of the Cork Brick-works, Ballanhissig.

The stones, the heaviest loads, always descend on the 6-inch rope, while on the parallel rope a balance load is run, which the stones descending draw up, thus considerably reducing the necessary brake power. This system of working is necessary only in the transport of the stones and very heavy loads. Each rope is used indiscriminately for the transport of lighter loads. It is estimated that the working strain on the 6-inch rope is about 30 to 34 tons, and that on the lighter rope 25 to 27 tons.

On each fixed rope is placed one carrier. That for carrying stone is fitted with an eye, to which the Lewis bolts in the stone are shackled; that for the balance load is fitted with a receptacle capable of containing 2 tons of ballast or chalk, and, in addition, is

fitted with a wooden shield with doors. The lower portion, which holds the ballast, is arranged to tip without disturbing the upper portion or shield, which, when the receptacle is empty, is employed for the carriage of about a dozen workmen.

Fig. 194. Support for Ropeway of Messrs Borner & Co.

A similar receptacle and shield can be attached to the carrier provided for carrying stone on the 6-inch rope when the carriage of workmen or of ballast, cement, &c., is required.

Attached to the two carriers is a running head, which has four steel wheels, which run on the fixed rope. These wheels are articulated in pairs, so that each has an equal pressure on the rope. Attached to each of these carriers is a hauling rope, which, on

Fig. 195. Unloading Station of Ropeway on the Roe System

arriving at the upper terminal, passes over a pair of 6-foot pulleys, and thence is led to a brake gear in the rear. Attached also to these carriers is a balance hauling rope which is led to the lower terminal, and, passing over two 4-foot guide pulleys, is led round an

8-foot return wheel, which, as has been stated above, is carried on the frame on which the tightening gear slides.

The brake gear consists of two 8-feet diameter wooden grooved wheels, each fitted with a brake sheave, the whole being carried on a vertical shaft. These brake straps are supported on one standard, and brought together at the other standard by means of levers working in opposite directions operated by screws. A suitable suspension arrangement was provided to keep the brake straps free from the flanges of the brake ring. Subsequently, owing to the necessity of applying steam power for bringing up workmen, &c., a bevel rim was fitted to the lower brake wheel, which, working in conjunction with a bevel pinion carried on a shaft, in connection with a steam engine, is employed when it is necessary to work the line by steam.

Fig. 196. General View of the Ropeway.*

As it is necessary that the man who works the brakes shall have a full view of the movement of the carriers, chain wheels are fitted to the screws which operate the brakes; these communicate by chains with two other chain wheels with hand wheels fitted to the trestle frame which stands at the edge of the cliff.

The hand wheels are placed close to one another, so that when the brakesman is operating the ropeway with one brake, he has another immediately in reserve should anything fail. As a matter of fact, one brake strap will control the load; the other, therefore, serves as a spare one.

The hauling rope passing round the upper brake wheel returns and passes round the tension wheel, then again returns to the brake gear, passes round the lower brake wheel, and in its turn is led to the head wheel and down to the carrier to which it is connected.

* The blocks of Figs. 196-210 inclusive are Messrs Bullivant's copyright.

For the loading of heavy weights, a lift, worked by hand, is provided in the loading position of the carrier on the 6-inch rope, which, as stated above, is the only one employed for the carriage of stone. The lift, which is fitted with a moving platform, provided with rails, is supported by locking gear in a position which brings the stone from the depot on the rails of a tramway. This having been done, the load is raised by operating a twin-grab winch, which simultaneously moves four ropes attached to the four corners of the platform. As soon as the stone has been raised sufficiently high it is shackled to the running head, and the platform with the truck is allowed to descend slowly into a pit, which is sufficiently deep to allow the stone, suspended from the carrier, to pass over the platform and empty truck. As this platform and truck descend slowly, the strain is allowed to come gradually on the carrier, and therefore on the ropeway. After the carrier has departed with its load hanging from it, the platform of the lift is raised, with the empty truck on it, and arriving in locking position, the truck is run off. This operation is repeated every time a stone is sent down.

Fig. 197. View looking up Ropeway.

Figs. 199 and 200 show the conveying and putting in place of the last stone.

The erection at Beachy Head was carried out by the contractors under the supervision of Mr Havelock Case, M.I.C.E., resident engineer for the Beachy Head Lighthouse Works.

Ropeway Constructed for the Port Elizabeth Harbour Board.—This ropeway was made to the order of the Port Elizabeth Harbour Board, and was installed for conveying dynamite from an isolated staging in the bay to a depot on shore.

As it was desired to separate the carriage of dynamite from the carriage of other goods on the existing piers, a separate landing stage was provided, alongside which barges and small vessels could lie; from here the dynamite was taken and by means of the ropeway carried over the water and surf to a terminal on land adjoining the store.

Fig. 198. Men Returning from Work.

It will be noticed from Fig. 201 that a few iron supports were placed in the sea, and that a terminal, also constructed of iron, was fixed on the staging in deep water, while a terminal built of timber was fixed inland near the depot for dynamite. The posts between this latter terminal and the seashore were made of timber.

In order to raise the dynamite from barges and ships lying alongside the staging, the movement of the hauling rope was also employed to operate a crane capable of raising dynamite in suitable loads from the low-water level.

The motive power was steam, placed at a distance from the landing terminal, so as to remove all sources of danger from the dynamite depot.

The quantity carried per hour was about 20 tons, but this could be increased by the addition of further carriers.

Fig. 202 gives a view of the driving terminal.

This ropeway did good service in the landing of war material during the progress of the war in South Africa.

Ropeway of the Liverpool Corporation.—This ropeway was made to the order of Mr J. A. Brodie, the engineer of the above Corporation, for the purpose of conveying concrete from the side of the dock for the building of a road bridge over it. For this

Fig. 199. Last Stone.

reason the arrangement of the ropeway was somewhat out of the common. It was 350 feet in length, and the terminals were made of a special width in order to distribute concrete over the whole area of the bridge.

The quantity carried was about 40 tons per hour, the concrete being mixed at the side of the dock, filled direct into the carriers, and transported to the point at which it was to be used, each carrier holding about 4 cwts.

Hoppers were provided, into which the concrete was tipped and led by shoots to the exact points required. By the use of this system of carriage a very short time elapsed between the moment at which the concrete emerged from the mixer and that at which it was shot into position.

Fig. 203 shows a portion of this ropeway, whilst Fig. 204 shows the driving terminal.

Ropeway in the Anaimalai Hills. — The Anaimalais (elephant mountains) of Southern India are an important centre of timber supply. The forests in this region, though much overworked in the past, still contain a large supply of exploitable wood of valuable kinds, chiefly teak, which is handled by a wire ropeway. The climate being unhealthy, this range of hills is almost uninhabited by man, but is infested with wild animals.

Under the system formerly employed in working these forests, the huge logs were

Fig. 200. Last Stone being put in Position.

dragged by elephants from the felling compartments to the side of a 2-foot tramway, and transported on trolleys to the end of the line, whence they were sent down the ghaut road by bullock carts into the nearest town, about 50 miles distant.

These methods have been reformed by the establishment of a saw-mill in the forest, driven by a Pelton water wheel, where the timber is sawn into marketable sizes. By the erection of a wire ropeway overlooking the plains, the use of the ghaut road—the most costly section of the journey—is dispensed with. The wire ropeway takes off from the lower end of the tramway line, while its lower terminus is close to the main road. The

sawn wood is conveyed from the saw-mill by the tramway direct to the wire ropeway, and in this way reaches the foot of the mountain.

The ropeway was erected by Bullivant & Co. for the Forest Department of the Madras Government. A loaded carriage travels down a main fixed rope by gravitation, hauling up an empty carriage on the same rope. The two carriages meet in the centre and are there transferred by an arrangement described below. The descending carriage is controlled by an endless hauling rope adjusted below the main rope, passing twice

Fig. 201. General View of Ropeway.

round a brake drum, and kept in check by a powerful brake strap, and a large deeply grooved wheel at the foot.

Fig. 205 shows the brake drum from the front.

The hauling rope is clipped on to the two carriages on the right-hand side, looking in the direction in which each is travelling.

The ropeway between the terminals is 6,318 feet long, and the length of line actually traversed by the carriages 5,284 feet.

It became necessary to advance the starting platform sufficiently to bring the central or transfer platform on to a ridge within easy distance of the rope. The total fall from terminal to terminal is 1031·58 feet; that from the upper terminal to the starting platform, 109·50 feet; from the starting platform to transfer staging, 488·70 feet; from the transfer staging to the lower terminal, 433·38 feet. The rope crosses two main valleys and a number of ravines, the ground being much broken up and rocky in parts.

There are six main spans of 554, 1,675, 510, 600, 355, and 712 feet respectively. The rail rope is $2\frac{7}{8}$ inches in circumference, while the hauling rope is $\frac{7}{8}$ inch in

circumference. This rope can be seen in Fig. 206. The brake drum is 4 feet inside diameter.

The brake strap is adjusted to the upper half of the drum and acted on by a handle at the side. The lower part of the drum is cased with hard wood and hollowed out to prevent the folds of the rope overlapping.

The axle of the drum runs easily in deep substantial bearings. The large grooved wheel at the foot is 4 feet in diameter.

The hanging supports consist of two curved wrought-iron plates 3 feet long, forming

Fig. 202. View of Driving Terminal.

a circular opening at the top 8 inches in diameter, and connected at the lower end by a grooved saddle in which the rope rests, sloped at the ends to prevent injury to the rope.

Fig. 206 shows a support.

The saddles are of cast iron, of similar construction, and are used in a few places, resting upon wooden brackets and supports projecting from them conveniently near the line.

The carriage consists of two curved wrought-iron hangers, connected together by pieces of timber with grooved runners, 9 inches in diameter, with $1\frac{1}{2}$-inch grooves. The carriages were first used with two wheels, as shown in Fig. 207, but experience has shown that it is best to use four wheels.

Four clips are attached to each carriage. Each clip is provided with a clamping screw, while the hauling rope is attached to the right-hand side of the descending carriage.

The nearer the wheels are brought together the more easily the carriages will travel.

When the wheels are placed some distance apart, they do not travel on the same plane, and set up much friction on the rope.

The first step towards the installation of the wire ropeway was the selection of the most convenient line, and clearing it—a by no means easy matter, as it lay through thick forest. The supports were then set up.

The unreeling of the rope followed, commencing of course from the bottom of the line. This was sent out on a large iron reel or bobbin, the total weight of the rope and reel being about 4 tons. An axle was passed through a hole in the centre, and the reel was swung clear of the ground.

It was at first intended to unwind the rope and carry it uphill on the shoulders of coolies, placed at intervals of 30 feet, but the broken nature of the ground made this

Fig. 203. View of Ropeway over Dock.

difficult, and eventually elephants were attached to the end of the rope to haul it up. The friction caused by the rope dragging along the ground was, however, so great, that at the end of the journey no less than nine elephants were at work in addition to a large body of coolies.

Spliced into the end of the rope was a massive thimble, or eyelet. This was attached to the chain, and the rope was fixed to its upper anchorage. It was then raised on to the supports, connected to the anchorage cable at the lower end, and hauled in by means of a winch, provided with the necessary two and three sheave blocks. Sufficient tension was obtained to give a dip in each span of about 1 in 40.

The unreeling of the hauling rope followed, and the two ends were joined. This

rope is of course adjusted below the fixed rope, and drawn reasonably tight. The up-and-down sides are arranged 18 inches apart, corresponding with the distance between the inner edges of the clips on the carriage, and kept in that position by means of fixed guide wheels, which lead the rope to the drum shown in Fig. 205 and large wheel at the foot. It was a matter of some difficulty to overcome the friction set up in this rope, which of course checked the loads. The design of rollers had to be changed several times, the last and most successful being large grooved pulleys, about 18 inches in diameter, running easily on their bearings, and provided with wooden guides placed above them to lead the haulage rope into the grooves.

The supports for the hangers and saddles vary in height from 8 to 75 feet, and

Fig. 204. View of Ropeway showing Driving Gear.

consist as a rule of two uprights and a stout 8-inch crossbar. In a few instances standing trees have been utilised as uprights.

Fig. 208 shows the highest upright, 75 feet from ground to top of saddle, and this support is the upper end of the longest span of 1,675 feet.

There are four platforms :—

1. The brake platform, 22 by 15 feet, placed 30 feet to the rear of the starting platform.

2. The starting platform, 19 by 20 feet (see Fig. 207), provided with tram rails, at the end of which is a weighing machine to ensure a uniform weight of the loads.

3. The central or transfer platform, 40 by 8 feet, and 4 feet high, placed at a distance of 10 feet from the line of the fixed rope. A trolley runs on this platform provided with a long wooden lever supported by a chain. A crossbar is attached to the

end of this lever corresponding in length with that of the carriage, and fitted with two upright iron plates to pass in between the wheels and the hangers of the carriage. The height of this platform is so arranged as to bring the lever, when horizontal, to nearly the level of the carriage. This is illustrated in Fig. 209.

4. The lower platform is 28 by 8 feet, and 5 feet high. It requires no description. The height is conveniently arranged with reference to that of the fixed rope.

The method of working the ropeway is as follows:—The weight of the load has hitherto not been allowed to exceed about 22 cwts. of timber, and though it is possible to

Fig. 205. The Brake Drum, Front View.

send down rough logs of that size, the work has been confined to the transport of railway sleepers and sawn scantlings of different sizes.

Fig. 210 shows a loaded carriage passing a hanger.

Fig. 207 shows a load of seven railway sleepers attached to the carriage, while the next load is ready in the trolley. As soon as it is ascertained that all is ready below, that is to say, that the previous load has been removed and the haulage rope clipped on to the empty carriage for the ascent, the hauling rope is detached from the left-hand side of the loaded carriage and lowered on to the rollers below, and the carriage is started, descending at high speed, some 20 miles an hour, to the central station, being kept under control by the brake drum. The two carriages meet here and are stopped at a distance of about 10 feet from each other, according to the length of the scantlings. The trolley and lever are then brought opposite to the empty carriage, and the crossbar engages it; the outer end of the lever is pressed down to raise the grooved wheels off the rope and

then pushed forward for a few inches to clear it. The lever is then raised at the end, and the empty carriage, with the hauling rope attached to it, falls downwards slowly, till it is low enough to clear the loaded carriage. The latter is then advanced slowly, and the trolley with the empty carriage comes forward on the rail a corresponding distance, and by means of the lever the carriage is raised and replaced on the rope.

The slow forward movement of the loaded carriage is obtained by means of the

Fig. 206. A Hanging Support.

brake drum, which is provided with gearing as shown in Fig. 205, while the drum is slowly revolved by hand. The carriages are again started, and the arrival of the empty carriage at the starting platform indicates that the load has reached the foot.

The supporting chains are provided with a hook and ring always placed on the outside, so that they can be released at once when the load becomes detached. The hauling rope is then removed from the clips on the right-hand side, and the up rope

placed on those of the opposite side of the carriage, the same procedure being followed at the starting platform, and the new load is immediately attached, after taking the precaution above mentioned to prevent the premature slipping of the carriage.

The line is kept clear of growth, and the starting platform is so arranged that the central platform is easily visible from it. Flag signalling is found to be the quickest, easiest, and safest method, and the brakeman is kept in communication with the look-out man on the platform.

This method of transferring appears to be somewhat primitive, involving the use of superfluous manual labour, but in the opinion of Mr H. H. Gass it is the best means of working, and is preferable to an automatic arrangement, which, he thinks, would be

Fig. 207. The Starting Platform.

certain to come to grief continually, and cause both carriages to fall off the rope. The lever arrangement works well and expeditiously.

The loads can be run down at the rate of about two an hour, and the saving is very considerable, so that if it were possible to work throughout the year with sufficient material, this ropeway would show a handsome profit. Its output of work is far in excess of that of the saw-mill, and it can be worked in all weathers.

It was at one time feared that damage might be done to the ropeway by wild elephants, as the hauling rope is within their reach in many places, but though they are often on the line, no damage has been done hitherto.

The ropeway has been a great success, but its construction in such a part of the country was beset with difficulties, because of the heavy weight to be moved,

and the absence of skilled labour, the only available labour being that of the aboriginal tribes.

The single rope was adopted in order to save expense, and as the working season is short, and a single rope can easily cope with the quantity to be dealt with, the addition of a second rope may well be deferred for some years until the present rope is so worn as to be unsafe for heavy loads, when it can be used for the upgoing empty carriages.*

Fig. 208. The Highest Support.

The Otto System has been mentioned in the beginning of this chapter, and was introduced by Pohlig, of Cologne, and Bleichert, of Leipzig.

The "Otto" is a double line consisting of a heavy fixed rope of large section for carrying, whilst the hauler is a light-running rope. As compared with other

* See description of this ropeway by H. H. Gass in *Page's Magazine*, August 1903.

modern ropeways, the "Otto" system presents no particularly distinctive features, yet the details of construction covered by the "Otto" patents embody some valuable improvements. The patent lock-coil rope which in this system has been largely substituted for the old type of spiral rope is here illustrated (see Figs. 211, 212, and 213). It is undoubtedly possessed of great strength, and has been installed under conditions involving heavy work and great strain on the ropeway.

Mr R. E. Commans has described the construction of an Otto ropeway which is at work at the Lake View Gold Mines in Western Australia. This ropeway is employed to transport ore from bins erected alongside the shaft to the top of the 50-head stamp mill, situated at some distance off on the hillside. The ore, as raised from the mines, is

Fig. 209. The Central or Transfer Platform.

dumped over a screen, the fines falling direct into the bins below, while the heavy pieces fall into a breaker, to be further crushed before passing into the bins through which the ore is rapidly delivered by several shoots into the ropeway buckets. The object of placing the mill on the hillside was to secure the advantage of natural gravitation in dealing with slimes and tailings. (This ropeway is illustrated in Fig. 214)

The carriers, like most modern appliances of this type, are suspended slightly below the centre of gravity, so as to permit of easy tipping and discharge. They are attached to hauling ropes by grips which are thrown in and out of gear automatically, and released at the unloading stations. Otto ropeways have been erected for capacities varying from 50 to 2,000 tons per day of ten hours. Sometimes when considerable quantities have

to be transported a double line is built, although a single line built recently in Lorraine, at Kneuttingen, having a length of about 6 miles, transports some 1,428 tons per day of twenty-four hours. As already seen, ropeways have been carried over longer distances than this, about 20 miles having been spanned in different parts of the world.

Examples of Otto-Pohlig Ropeways.—A few examples of ropeways on the "Otto" system, erected by Pohlig, of Cologne, are given in the following pages.

Fig. 210. Loaded Carriage passing a Hanger.

Fig. 215 is a typical example of a long single span, the distance between the supports being 875 yards. The ropeway is that of the Brick and Tile Works, Friedrichssegen, Ems, Germany, the total length of which is 2,363 yards.

Fig. 216 shows a span of 306 yards of the ropeway in the Bedar Mountains, Garrucha, Spain.

Fig. 217 gives a view of an angle station, at which the ropeway, by describing a curve, changes its direction. It is erected for the Wissener Mining and Smelting Co., near Wissen, Germany. The construction of the angle station allows the carrier to remain on the rope during its passage through the curve without the aid of shunt rails, thereby dispensing with attendance at this station. The total length of the ropeway is 4,500 yards. It is used for the transport of iron ore.

Fig. 218 shows another view of the same ropeway representing a long span over

a river. The ropeway passes obliquely over a bridge, and is supported by the trestles on the opposite bank. The safety net for the protection of the bridge is also visible.

A loading station for the transport of clay is shown in Fig. 219; also a portion of a small branch line, resting on portable trestles. This, however, is a suspended railway on which the carriers often travel to and from the ropeway on a single rail. This branch line can be removed to any required position for working. This installation is at work for the Société Anonyme des Usines Dufossez et Henry, Cronfestu, Belgium.

Fig. 220 gives a view of a ropeway for the transport of timber erected in a very mountainous district in Hungary, on the estate of Count Nicolaus Thorotzkay, and in connection with the saw-mills of Csimpa. The length of the line is 12½ miles. The loading station is at an altitude of 4,600 feet, whilst the unloading station is at an altitude of 2,300 feet. The highest ridge traversed by the ropeway is 5,400 feet. Thirty-five loads are transported per hour. The ropeway is divided into four sections. The greatest incline is 45 per cent., while the average fall is 3·4 per cent. The working of this ropeway is automatic, and no driving power is required, except for the starting of the plant, for which a 24 HP. steam engine has been provided. There are 205 trestles to support

Fig. 211. Fig. 212. Fig. 213.

Sections through Lock-coil Rope on the Otto System.

the whole of the line, the highest being 80 feet. The first three sections were started to work in 1896, while the remaining length was erected in 1898.

Fig. 221 represents a portion of a ropeway erected in the Isle of Elba for conveying ore from the mines to the coast. At the loading terminal, which is seen in the distance, the contents of the skips are tipped into vessels.

Fig. 222 shows the loading terminal of a ropeway for conveying ore for the blast furnaces of the Niederrheinische Hütte, at Duisburg Hochfeld. The terminal is reached by the aid of two cranes which lift the ropeway skips out of the barges on to the lines of the ropeway.

Fig. 223 illustrates a portion of a ropeway executed for the Dutch Government, in Java. This line has been erected for the transport of stones. The length of the ropeway is 10,000 yards. It is built on the Otto-Pohlig system, and there is a difference between the levels of the terminals of 123 feet. Owing to the incline a 17 HP. portable engine is sufficient to drive the line.

An interesting example of a very tall wooden trestle is shown in Fig. 224, which is a portion of a ropeway in New Zealand, built by Pohlig.

Figs. 225, 226, and 227 show portions of the ropeway of the Mount Lyell Mining and Railway Co. Ltd., of Strahan, Tasmania. The line is built on the Otto-Pohlig system, and is 2,600 yards in length. It has a capacity of 60 tons per hour. The illustrations explain themselves.

Fig. 228 shows a method by which a high dump can be effected between two stations. The buckets in this case are arranged to tip automatically at any given point along the line. This arrangement is particularly useful in the neighbourhood of collieries and mines for the disposal of the refuse. It is also in use on the Rand, where the space available for the tailings is limited, as it admits of the disposal of thousands of tons of tailings over a comparatively small area and at a low cost.

Ropeway between the Hilltop Colliery, Durham, and the Coke Ovens at Malton.—Portions of this ropeway are illustrated in Figs. 229, 230, and 231. Fig. 229 shows an intermediate angle station, the weights for keeping the rope taut being clearly shown on the structure. Fig. 230 is also a portion of the same ropeway, showing a safety net stretched between two of the trestles over some buildings.

Fig. 231 represents the delivery terminal at the coke-oven end. The coal on arrival at this station is either tipped into railway trucks for sale, or crushed by a disintegrator, and afterwards elevated to the hopper, from which it is trammed to the coke ovens.

Colonel S. A. Sadler, M.P., proprietor of the Malton Colliery, entrusted the erection of this ropeway to Mr R. E. Commans, the English representative of Messrs Pohlig. It has been erected on the Otto-Pohlig system, and is one of the longest ropeways in this country, having a total length of 3,520 yards.

Henderson Ropeways.—An interesting installation, built by J. M. Henderson & Co., of Aberdeen, on the single rope system, has been erected in Tasmania. The ropeway is 3,432 feet long between the terminals, and is used by the North Mount Lyall Copper Co. Ltd., Gormanstown, Tasmania, for conveying copper ore. The capacity is 60 tons per hour, and the inclines about 1 in 5. There are a hundred buckets in use, supported on eight trestles, the highest of which is 77 feet, whilst the lowest is 24 feet. The accompanying illustration shows one of the high trestles.

Fig. 214. Ropeway at Lake View Gold Mine.

Bleichert's Ropeways.—Fig. 233 represents an iron standard with a portion of a double ropeway, erected by Messrs Bleichert & Co., of Leipzig, for Messrs Crookston Brothers, Bône, Algeria.

Fig. 215. Span of 873 yards of an Otto-Pohlig Ropeway at Ems, Germany.

Fig. 216. Span of 306 yards of a Ropeway in the Bedar Mountains, Garrucha, Spain.

Fig. 234 illustrates a ropeway for feeding furnaces, also the work of Messrs Bleichert & Co.

Fig. 235 represents a portion of a ropeway between the wrought-iron support and the first standard, which is also of wrought iron. This ropeway is for the transport of iron ore, and was erected for the Marienhütte Gollnitz, Hungary, by Messrs Bleichert & Co. The capacity of this installation is 25 tons per hour.

Fig. 236 shows one of the wooden supports for the same ropeway.

*Wright's Ropeways.**—Extensive wire-rope installations have also been erected by Messrs J. & E. Wright, of the Universe Works, Birmingham. Amongst these may be

Fig. 217. Angle Station of Otto-Pohlig Ropeway, near Wissen, Germany.

mentioned the aerial ropeway at the Tottington Mills, Lancashire, employed for conveying cloth from the dye to the finishing works, the length of line being 1,600 feet. Also the ropeway used by Messrs J. & J. M. Worral Ltd., Salford, for the carriage of cases of goods, the length of line being 780 feet.

Systems in Use Abroad.† – Amongst installations abroad may be mentioned those on the "Gourjon" system, one of which is erected at Tiel in France, and one at St Imier, near Grenoble, the former being 1,558 feet in length, and the latter 8,200 feet.

* See Hipkin's "The Wire Rope and its Application" (Birmingham, D. F. Tayler & Co. Ltd.)

† For further descriptions of above systems of ropeways see "Aerial or Wire-rope Tramways," by A. J. Wallis Tayler.

Fig. 218. Portion of Otto-Pohlig Ropeway near Wissen, Germany.

Fig. 219. Ropeway Terminal, with Branch Line, Belgium.

Fig. 230. Portion of an Otto-Pohlig Ropeway for the Transport of Timber.

Fig. 221. Portion of a Ropeway in the Isle of Elba.

Fig. 222. Loading Station of an Otto-Pohlig Ropeway.

Fig. 223. Portion of a Ropeway erected for the Dutch Government in Java.

A noteworthy system is that described by Messrs Hauet, an installation of which is at work in the chalk pits near Paris, conveying chalk to a distance of 500 to 820 feet.

The "Beer" system, at work at the Seraing furnaces of the Esperance-Longdoz Co.,

Fig. 224. Example of a Wooden Support on an "Otto" Line in New Zealand.

and the "Obach" system, which is at work at the blast furnaces at Vajdahunyad, are both worthy of note, the length of line in the latter being 100203·21 feet.

A series of experiments have been made, and as a matter of fact small installations

Fig. 225. Plan of the Mount Lyell Mining and Railway Co.'s Ropeway in Tasmania.

Fig. 226. Portion of the Ropeway of the Mount Lyell Mining and Railway Co. in Tasmania.

Fig. 227. Portion of the Mount Lyell Mining and Railway Co.'s Ropeway in Tasmania.

of electrically driven rope and cableways have been executed, one of which is at work at Glynde in Sussex, and the other at Weston in Somerset. This method of driving, which is known as Telpherage, was first introduced by the late Professor Fleeming Jenkin. It possesses undoubted advantages, but is as yet only in its infancy.

2. **Cableways or Cable Hoist Conveyors.**—An interesting development of the ropeway is the cableway, which may be defined as a hoisting and conveying device, employing as a trackway a suspended cable in one span. The term cableway is of American origin, as also is this special application of the process to conveying heavy material by means of ropes. The cableway is designed to hoist and convey single loads for a comparatively short distance. It may either be simply a conveyor such as would

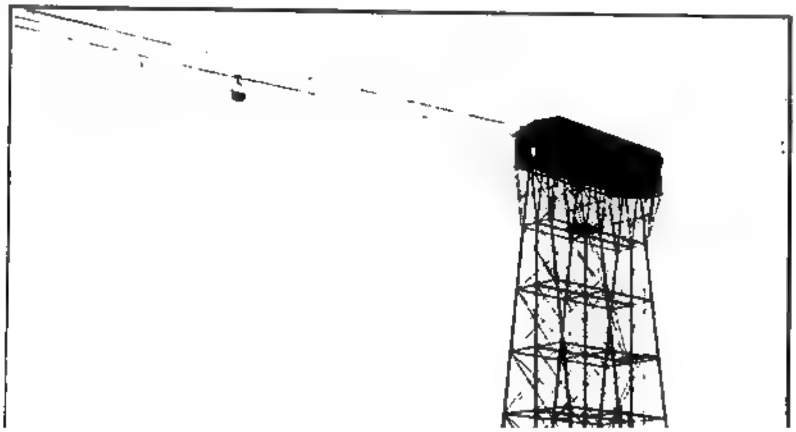


Fig. 228. Method of effecting a High Dump between Two Stations.

be used for transferring material across a river or ravine, or it may be used more particularly for hoisting, in which case it is very suitable for loading and unloading vessels, for quarry work, canal and dock excavation, harbour work, &c., in all of which cases an ordinary derrick would be unsuitable because the radius described by it would be too limited.

This type of cable hoist conveyor is made in two designs, one suitable for inclines only, in which the carriage descends by gravity, and the other (the more important of the two) applicable either to horizontal lines or to lines where the incline is not sufficient for the carrier to descend by its own gravity, in which case the hoisting and conveying are effected by means of two separate ropes. In either case the rail rope rests upon saddles of hard wood or iron on the tops of the terminal towers, which are anchored firmly at each end. At one of the anchorages a tightening arrangement is generally provided for maintaining the rope sufficiently taut. The terminal towers are made of wood or iron, and are similar to the trestles used for ropeways; or if the conveyor is a

Fig. 229. Intermediate Tightening Station of the Ropeway between the Hilltop Colliery, Durham, and the Coke Ovens, Malton.

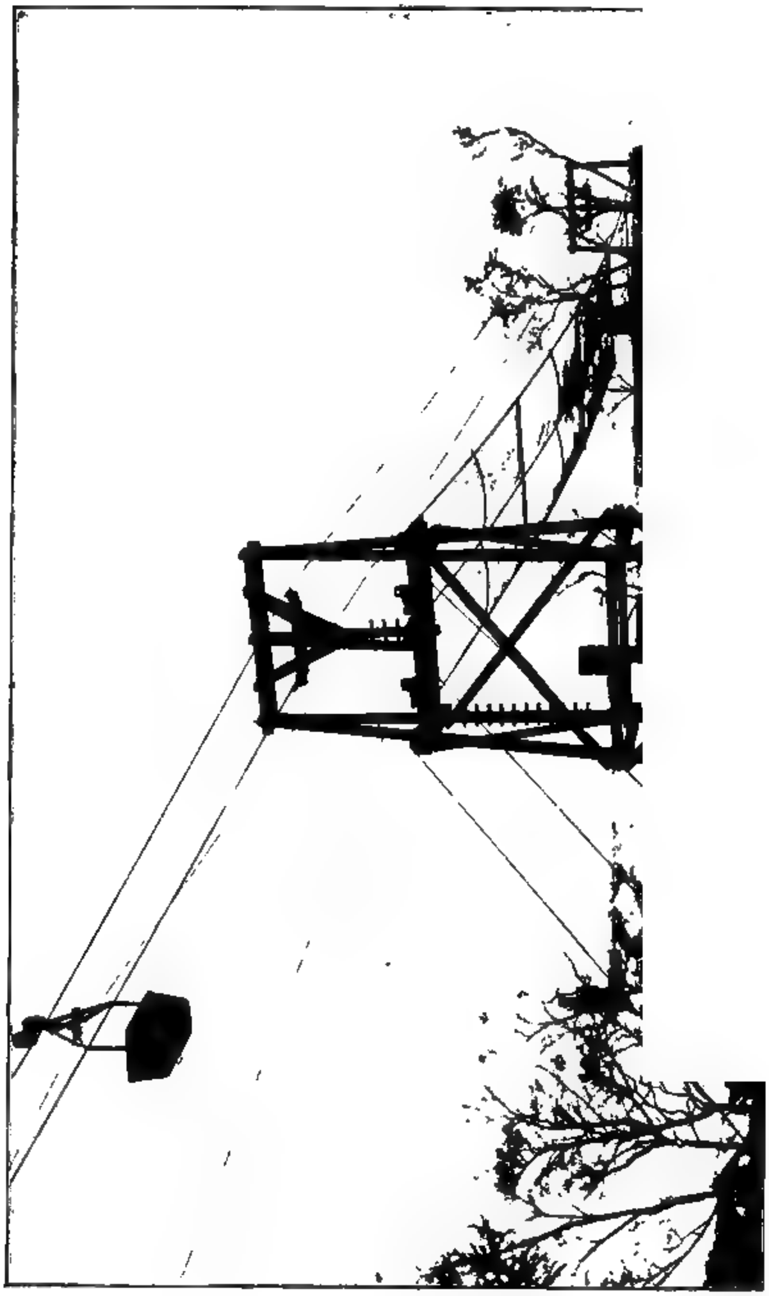


Fig. 230. Example of Safety Net for Otto-Pohlig Ropeway at Multon Colliery.

short one, ordinary shear legs held in position by guy ropes and cables are sometimes sufficient. The same kind of conveyor can be made portable by mounting the terminals upon trolleys. This is a great convenience in some classes of work. Motive power can be provided either by steam engine or electro-motor.

Lidgerwood's Cable Hoist Conveyor.—Fig. 237 is a cable hoist conveyor of this type, built by Bleichert & Co., of Leipzig, in which the rail rope is sufficiently inclined to allow the carriage to descend by gravity. One rope only is required in this case to manipulate the hoist, which is used for quarry work.

Fig. 238 is a hoist of a similar kind having two principal terminals for unloading. Although there is a slight incline, it is not sufficient to allow the carriage to run back on its own account. Two ropes are therefore necessary for the purpose of manipulating it, in addition to the rail ropes. This hoist is designed by the same makers.

Fig. 231. Delivery Terminal at the Coke-oven End.

Fig. 239 is a similar installation by the same engineers, in which one terminal is fixed, whilst the other can be moved in a circular direction.

Fig. 240 shows a hoist of a slightly different kind, provided with wrought-iron terminal towers mounted on wheels, also the design of Bleichert.

Cableways of the Lidgerwood Manufacturing Co.—The cableway has been brought to great perfection by the above-named firm. The first travelling cableway constructed by them dates from 1890, and was made for the Chicago Drainage Canal. It proved so efficient that its erection was speedily followed by that of nineteen similar plants. The specification in this first order comprised an apparatus capable of moving in a direction parallel to the proposed cutting at the rate of 2½ feet per day and having a daily capacity of 300 cubic yards.

In one month the material handled by one of these installations amounted to 10,821 cubic yards, while with the same cableway during one week's running 1,854 skip-loads were removed in sixty hours.

The ordinary type of Lidgerwood cableway consists of a cable carried between two supports, known respectively as the head and tail towers. The head tower, which contains the engine, is generally higher than the tail tower, sometimes as much as 20 feet, whilst the span between the two, though necessarily variable, has been known to be over 2,000 feet. The main cable, on which the carriage travels, is of steel, and has a circumference of $2\frac{1}{4}$ inches, while the other ropes are of suitable size for handling loads of 8 tons. A three-wheeled traveller is used, while "Miller" fall-rope carriers are arranged to accommodate an extra rope for dumping, and thus render it easy to quickly lower the empty fall block at any point.

Fig. 232. High Trestle of the Ropeway of the North Mount Lyall Copper Co., Gormanstown, Tasmania.

The dumping or discharging, which is a special feature of the cableway, is effected by an auxiliary rope called the dump line, which is attached to the rear end of the skip or tray. When it is desired to dump, this line is drawn in at a higher rate of speed than the hoisting rope, and the load thus discharged without checking the onward progress of the carriage on the cable. Each tower is moved by a pair of small reversible engines with 6 by 8 inch cylinders. On the head tower steam was taken from the main boiler, while on the tail tower the practice was to work the engine by compressed air from the drill pipe running along the canal. A $\frac{3}{4}$-inch diameter steel rope was stretched under the centre of the tower parallel to the line of the canal, for several hundred feet, and anchored firmly at each end. A bridle led from under the tower in each direction. The ends of this bridle were attached to the timbers of the tower, one end under the inner posts, and the other to the timbers carrying the rear axles. A pair of single blocks were attached to the bridle and to the anchorage line on either side. A rope was threaded through the single blocks on one side, then passed several times round the drum of the engine, and threaded through the blocks on either side, as shown in the illustration, Fig. 241. The engine being reversible, the tower might be moved in either direction at a normal speed of about 100 feet per minute.

The track may either be laid some distance ahead of the plant, or, as is more usual, 15-foot sections, which are transferable from one side of the car to the other, are used. Driving power is supplied by an engine with 10 by 12 inch cylinders, with cranks at an angle of 90 degrees to each other, and fitted with reversible link motion. The drums are of the Beekman patent friction type, with band brakes, and can be operated either together or separately. As the two drums are of the same diameter, the two ropes travel at the same rate of speed when both drums are revolving. Hence the load may be carried in either direction at a uniform distance from the cable. The drum for the endless traversing rope is turned with a curved surface, around which the endless rope is coiled four or five times to prevent it slipping in the opposite direction to that in which the drum is turning. The hoisting drum is divided into two parts, the wider part receiving

the main hoisting rope, and the narrow part the dump line. Between these two sections of the line is a third section of increased diameter, to which the dump line is shifted when the bucket or skip is to be dumped. The shifting mechanism is shown on top of the engine. All operating levers are together in a rack in a convenient position in the rear of the engine. This engine was designed to lift a load of 8 tons at a speed of 300 feet per minute, and to convey it along at a speed of 1,000 feet per minute or more.

Essential features in the Lidgerwood cableway are the travellers and the fall-rope carriers. It is claimed for the former that they are light in proportion to their strength, and are capable of hoisting 8 tons. All the wheels are brass bushed, and are self-

Fig. 233. Portion of the Ropeway of Messrs Crookston Brothers, Bône, Algeria.

lubricating. The fall-rope carriers have suitable wheels for supporting the hoisting or fall rope, the dump rope, and also the endless or hauling rope. They were designed and patented by Mr Spencer Miller, and are exclusively used on all Lidgerwood cableways. They ride on the horn in front of the carriage until displaced by the steel buttons on the button rope. The spaces in the carriers are graduated in size, as are also the buttons. Thus each button will pass through every carrier except the one which it is intended to pull off the horn of the carriage. The buttons being made fast to the rope at regular intervals, it is clear that as the carriage passes along the carrier will be displaced from the horn at each button, and hence the ropes will be perfectly supported; but as the carriage moves in the opposite direction, the carriers should be picked up by

the horn on the carriage as soon as reached. The importance of these fall-rope carriers will be the more evident when it is considered that if the fall rope were allowed to sag

Fig. 224. Ropeway for Feeding Furnaces.

down for any distance it would be impossible to lower the fall block on account of the great weight of the sagging rope, to say nothing of the great wear on the rope through dragging on the ground.

Fig. 235. Portion of the Ropeway of the Marienhütte Gollnitz, Hungary.

Fig. 236. Wooden Support of the Ropeway of the Marienhütte Gollnitz, Hungary.

Fig. 237. Inclined Hoist Conveyor, as used for Quarry Work.

Fig. 238. Two-rope Cableway.

A few explanatory remarks on the mechanism by which this aerial dumping of loads is effected may not be out of place. The carriage is drawn along the cable by an endless or hauling rope which passes from the carriage over the head tower, and several times round the winch drum on the engine, to secure frictional hold, then back over the head tower to the tail tower, returning to the rear end of the carriage. The hoisting rope passes from the engine over the carriage to the large fall block for raising the load. An auxiliary rope, the dump line, comes from the other side of the same drum of the engine and passes to a smaller block attached to the rear end of the skip. The hoisting rope carries the whole weight of the skip, while the dump line comes in slack but at the same rate of speed. When the bank or other discharging destination is reached, the dump line is shifted to that section of the drum having an increased diameter, and being thus drawn in at a higher rate of speed, the load is discharged. It is stated that the dumping of the load does not check the speed of the carriage. The engine, being immediately reversed, the carriage will return for the next load with a minimum of delay. The button rope is placed just above the cable. One carrier is arrested by the button, the others having already been picked up by the horn of the carriage.

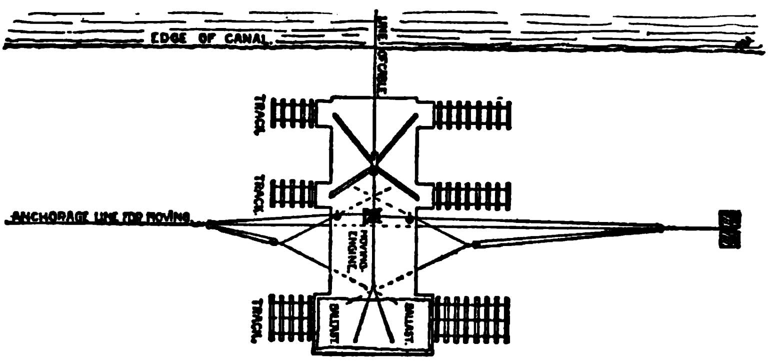


Fig. 241. Showing Details of Cableway as used by the Chicago Drainage Canal.

It is said that the total cost for labour, coal, oil, waste, &c., varies from £3 to £3. 15s. per day. The capacity may vary from 400 to 600 yards per day, so that it may be assumed that the cost per cubic yard for these items is about 2d.

Cableways may be used for a great variety of purposes. For instance, the Onomea Sugar Co., of Hilo, in the Sandwich Islands, have erected a cableway for handling cargo on a rugged coast where vessels often cannot get into the dock. The loads are swung over the small boats by a stationary derrick.

In mining enterprise the cableway has already played no inconsiderable part.

The Ottawa Gold Milling and Mining Co., of Lake of the Woods, Ontario, Canada, employ a Lidgerwood cableway to unload gold ore from lake barges and deliver it over the main line of the Canadian and Pacific Railway to their mill at Keewatin, Ontario. The span of this cableway is about 450 feet, whilst the load carried varies from 2 to 3 tons. A clearance of over 22 feet is given over the cableway, which is itself 20 feet above the lake. The tail tower, 75 feet high, stands on piles driven into the lake, and to these piles the cable is also anchored. The material is automatically dumped into the ore bins at an elevation of 43 feet, and at the rear of the ore bins is the 80-foot head tower, from which the operator has a clear view of the entire work.

The barges are moored under the cable between the tail tower and shore. A special feature of this cableway is a bell-hoist installed at the base of the head tower, which is driven from a line shaft in the mill, which is in turn run by water-power.

In the construction of marine and semi-marine works, such as breakwaters, locks, dams, &c., cableways have been used with good effect. At Johannesburg, in the Transvaal, the Consolidated Gold Fields of South Africa used a cableway in the construction of a masonry impounding dam intended to store water for the stamp mills on the Rand. The stone, concrete, and all the necessary material was conveyed and delivered into a ravine about 120 feet in depth, in which was built a dam of a total length of 500 feet, of a width of 46 feet at the bottom and 10 feet at the top, and of a height of 165 feet from the bottom of the foundation.

This cableway was used nine hours during the day and nine during the night, with only one day lost time in eight months. It regularly fed three derricks with all the building material, and assisted in laying stone during the day. Working at night, the cableway delivered 225 stones for the use of the derricks the following day. The average load was 3 tons. Cableways are much more portable than ropeways, and, if necessary, can be moved considerable distances at no great cost.

In placer mining the cableway has also been used, a case in point being that of the German Bar Mining Co., of Virginia City, Montana, U.S.A., which employs a radial cableway with self-filling and self-dumping buckets of 1½ yards capacity in working over the tailings of Alder Gulch. This cableway has a span of 400 feet. The load excavated and carried is 1½ cubic yards. The pivot tower contains a large hopper, the bottom of which is 40 feet above the ground. Through this hopper the material is delivered into a 30-inch sluice, 5 per cent. grade and 200 feet in length, which finally delivers the tailings at an elevation of 25 feet above bed-rock. This tower has a ball-bearing top or bonnet, so arranged with cables and guys that it will turn on its axis, allowing the travelling head tower to move through an arc of 180 degrees. This travelling tower permits of the excavation being made along radial lines, and a semicircular or fan-shaped pit is dug round the hopper tower which stands on bed-rock in the pit previously excavated. The tailings flow over this old pit in the rear of the tower. As soon as the semicircular pit has been excavated the entire plant is moved forward and another pit made in the same way.

The self-filling drag bucket used in cableways employed in placer mining is an ingenious development of the scoop or drag bucket principle. The carriage, with bucket hanging teeth downwards, is run out on the cable, and the bucket dropped at the foot of the bank. The bucket strikes the ground teeth foremost, settles down on its base, and as the carriage continues towards the head tower with the hoisting line slack, the bail falls back into its natural position, the back catch automatically locking itself ready for digging; but when the carriage has reached a point much nearer the tower than the bucket, the conveying drum brake is thrown in, and the carriage held stationary on the cable whilst the hoisting rope is tightened, thus giving to the bucket a long inclined draft, which enables it to fill. This draft may be varied by simply changing the position of the carriage with respect to the bucket. This power of altering the angle of draft is of course of great importance, because in this way the bucket can be exactly adapted to the character of the material and the required depth of cut.

There has been a tendency to run the earlier cableways at rather a high speed. The best speed, however, is from 500 to 750 feet for travelling, whilst for hoisting the speed should be about half, say from 200 to 300 feet per minute.

Henderson's Cableways.—In these cableways the terminal supports or frames for

carrying the main cables are made either of open lattice work of steel, or of pitch pine framework. These supports also carry the necessary saddles and tackle for the supporting ropes, as well as the brackets, shafts, guide pulleys, &c. The main cable and ropes are of steel specially constructed for cableway work. The rope fastenings are either spliced or clamped to the rope. The cables are held taut by means of some anchorage and the tension gear.

The loaded traveller or carrier (see Fig. 242) is usually provided with wheels; these are supported on an articulated frame which allows them to accommodate themselves to any curves the rope may assume. The traveller is fitted with the necessary connections for the travelling rope and guide pulleys for both hoisting and travelling ropes. Pulleys for button rope, and horn for button-rope carriers, are fitted when the latter are in use. On shorter cableways, two-wheeled load carriers are often used. The engine and the boiler with the necessary gear are carried on one of the terminal frames, or fixed on concrete foundations as required. The engine is of the two-cylinder, high-speed, reversible type. The hoisting drum and travelling wheel are carried on the same shaft, the former being keyed on, while the latter is loose on the shaft. The drum and travelling wheel are driven by separate spur gears from the main shaft.

The spur pinions on the driving shaft are fitted with adjustable band friction clutches for controlling the travelling and hoisting operations. Instead of the travelling wheel, a drum and double-grooved wheel may be fitted, according to the circumstances, and for some work sliding pinions may be used instead of friction clutches.

Some of Henderson's cableways are fitted with a device by means of which the skip can be emptied at any point by the operator in charge. The arrangement for this apparatus permits of an additional narrow drum on the winding gear, and a small wire rope between the traveller and the rear end of the skip similar to Lidgerwood's; also special slings, hoisting blocks, and controlling apparatus at the engines.

The winding gear and engines are fixed in such a position that the man in charge can have a good view of the track. When, however, this is impracticable, or when the ropeway is too long, an electric indicator is used similar to the domestic bell indicator, and is so placed as to be visible from the driver's seat. The indicator bell is connected to any part of the track where the operations are in progress by portable contacts which are marked to correspond with the indicator, so that the movement of the traveller can be observed by the operator.

Fig. 242 represents the usual design of Henderson's traveller or load carrier, and the accompanying numbering refers to the different parts shown in the diagram.

Two interesting examples showing the utility of the cableway for different classes of work are illustrated in Figs. 243 and 244. Fig. 243 represents three Henderson cableways with a span of 750 feet each, and for loads of 5 tons, the respective heights of head and tail towers being 60 and 50 feet, the engine cylinders having an 18-inch stroke and being 11 inches in diameter.

These cableways are used by Messrs Pearson & Co. Ltd. for excavating work at the Dockyards, Malta. The terminal on either bank and the progress of the excavating work can be clearly seen.

Similar installations are being employed at Gibraltar, Hongkong, and Simon's Bay, South Africa.

Fig. 244 shows a similar cableway with a span of 1,000 feet, and for loads of 2½ tons. The terminal towers are respectively 60 and 72 feet high. This cableway has been erected for the purpose of constructing a viaduct over the Cannington Valley for the Axminster and Lyme Regis Light Railway. The piers of the viaduct are being

erected without the use of any scaffolding, and solely by the use of a cableway. Som of the piers are 72 feet in height, and are composed of massed concrete.

Cableways of a similar design have been used for the construction of Vauxh Bridge and Kew Bridge. Cableways are also being used for the erection of viaduc at Kirkcaldy, Durham, and in Devon.

1. Main Cable.
2. Button Rope.
3. Travelling Rope.
4. Hoisting Rope.
5. Load Carriage Wheels on Levers.
6. Load Carriage Wheel.
7. Hoisting Pulley.
8. Hoisting Block (complete).
9. Small Guide Pulley for Travellin Rope.
10. Button-rope Pulleys.
11. Large Guide Pulley for Travellin Rope.
12. Rope Carrier Pulleys.
13. Pin for Rope Carrier Pulleys.
14. Rope Carrier (complete).
15. Button.
16. Tension Screw and Nut.
17. Oil-pot.

Fig. 242. Henderson's Load Carrier.

The "Calhoun" Cableway.—This deserves closer investigation, though it is some respects not unlike the cableways already described. It is built by D. J. Calho of Chicago.

Fig. 245 represents the skip being automatically filled, after being lowered at correct angle into a heap of coal. It is hoisted by the hauling rope from either of two terminal towers, similar to Lidgerwood's.

Fig. 245. Showing Action of Calhoun Cableway.

The travelling trolley is conveyed by the hauling rope to a predetermined po where a catch X has been fixed to the rail rope. This locks the traveller in position that the skip may be hauled up on the inclines of the stock heap and there filled. W the skip has been raised, the trolley disengages itself from X, and runs with its load to discharging point Y, where the skip is automatically emptied. In the illustration, poi X and Y are shown close together, but these can of course be fixed in any suita position. By means of a second hauling rope the trolley is again conveyed to the load


point, and on its way is arrested by the tripper Z, which only comes into play at the forward movement of the trolley, and has the effect of so disengaging the fall block with its skip that it again reaches the stock heap.

The trolley is shown in two views in Fig. 246, and consists of plates A and B, suspended on pulleys C and D. Between the plates is placed the sheave E, which serves to connect the loose sheave and fall block G with the trolley. When the skip is

Fig. 246. Travelling Trolley used on the Calhoun Cableway.

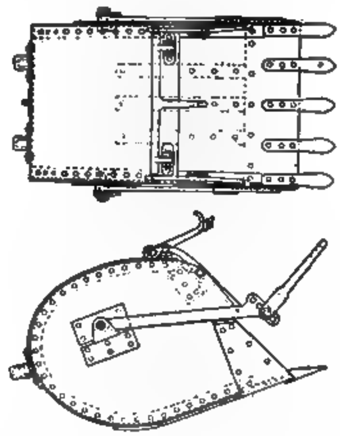


Fig. 247. Skip used in Calhoun Cableway.

on the ground, the surface *ab* of the part T, which is movable on the pin F, rests on the guides *cd*, which are attached to A and B, so that the pin *h* of the block G can catch in the recess *b*. If *ab* is resting on *cd*, the pawl L no longer rests on the point *e*, but will engage with the catch X on the rail rope (see Fig. 245), holding the trolley at the point *g*. As soon as the load has been raised, and *h* has thus engaged with *b*, the shield T revolves to the left round the pivot F, while the pawl L, which is controlled by springs, will be arrested at the point *e*, and the hook M releases the catch X, so that the horizontal movement of the trolley can commence. The throw-off apparatus Y is shown in Fig. 245, and consists essentially of the lever *ikm*. The running trolley strikes against the lever *i*, and at the same time the lever *k* engages the hook H on the skip (see Fig. 247), and thus effects the discharge of the same. On the return journey the pawl L comes in contact with the tripper Z, which disengages L from the point *e*, whereby the fall block G is disengaged from the trolley, and the skip dropped through the upward movement of the shield T.

Fig. 248. Large Scale View of Tripper.

Fig. 248 shows a larger view of the tripper Z. It may be noted throughout that all shocks are borne by the hauling rope and not by the rail rope.

The trolleys are built in three sizes to take skips of 15, 28, and 43 cubic feet capacity. The corresponding diameters of the main or rail cables are $\frac{1}{2}$, $\frac{5}{8}$, and $\frac{3}{4}$ inch.

An approximate idea of the capacity and working cost may be formed from the fact that the trolley can make the double journey of a track of 250 feet long in one minute. At this speed the largest skip can convey over 600 cubic yards of material in ten hours.

Three men are required to manipulate such a plant, and the coal consumption of the driving engines is said to be 1 to $1\frac{1}{2}$ tons per day under ordinary conditions.

The author is indebted to Professor Buhle for the foregoing description.

In addition to the cableways already mentioned, a noteworthy American system is the "Hallidie," which is employed on the cable tramway of San Francisco.

There is a tendency to introduce electrically driven cableways, which will no doubt have distinct advantages. They are, however, as yet not sufficiently perfected to allow of a full description being given.

3. **Coaling Vessels at Sea.**—The operation of coaling vessels at sea by specially constructed cableways has been fully dealt with by Mr Spencer Miller in two papers read before the American Society of Naval Architects and Marine Engineers on 16th November 1899, and 1900,* to which the author is greatly indebted for the following description.

A paper entitled "Coaling Ships in Squadron on the Open Sea" was delivered by Lieutenant R. S. Lowry, R.N., before the Royal United Service Institution, London, 13th April 1883. In Lieutenant Lowry's plan, special coal boxes or boats holding about a ton of coal were carried by a collier and conveyed to the warship by lines hoisted on deck, emptied and returned. These boxes were made buoyant by air-tight chambers. This system was fully discussed, but was evidently not considered practicable.

In 1887 a paper entitled "Coaling Ships of War at Sea" was read before the same Institution by Lieutenant C. E. Bell, R.N., and was fully discussed by Admiral Boys, the late Vice-Admiral Colomb, Commander Campbell, Captains Fitzgerald, Henderson, and others.

Lieutenant Bell remarked on this occasion that his excuse for putting his views before the Institution would be found in the utterances of Captain Scott, whom he quoted as follows: "I think, moreover, that you require, if you have groups of squadrons, some equal coaling power or means of coaling at sea which we have not yet hit upon." And then he says: "I feel sure that all officers will agree with me that coaling from broadside at sea is impossible, except in very calm weather, and that even then it is attended with great risk to both men and material employed." And, "I am sure I am supported in such belief by all who have considered the subject, that the only way by which the great difficulties and dangers of coaling at sea can be overcome and the work carried out successfully with the least possible delay, and absence of danger both to men and material, is by coaling from bow to stern." Also, "I do not make any claim to originality—in fact, I believe that the same idea has occurred to many officers who have given any consideration to this subject; and in fact, on submitting a sketch of the present plan to Sir J. H. Cammerell a short time ago, he then told me it had suggested itself to him some years back, and he believed it was the only way in which it could be done."

Bell's Requirements.—Lieutenant Bell says: "Any satisfactory plan of coaling at sea must satisfy the following requirements:—(1) Rapidity; (2) safety; (3) ability for the ships engaged in the operation to proceed with the minimum diminution of speed. These three requirements are absolutely essential to the success of any plan, but there are others of no little importance. (4) Necessity of keeping coal dry; (5) minimum of labour to be employed; (6) little cost for material necessitated."

Lieutenant Bell's Plan.—The plan suggested by Lieutenant Bell is that shown in Fig. 249, in which it will be seen that he first took the collier in tow of the warship, and then added an inclined and elevated cable attached low down to the aftermast of the warship and to the top of the foremast of the collier. To this elevated line a

* See also *Engineer*, 19th January and 27th July 1900.

trolley was suspended capable of running along the strand. Two ropes are shown, one fastened to the rear and one to the front of this trolley, the one leading to the warship and the other to the collier. The hawsers, in his system, are crossed from the stern of the man-of-war to the bow ports or other convenient places of the collier. He proposed to carry five bags at a time, carrying about 220 lbs. of coal per bag. The bags were to be hoisted, by some arrangement not shown, from the deck of the collier to the suspended cable, and there attached by a man stationed on the foreyard for that purpose. By these means he proposed to satisfy all the requirements he had laid out—namely, rapidity, safety, &c. In referring to the fact that his appliance costs but a trifle, he added: "I would at the same time insist that no expense should be considered too great to carry out this most important, I may say all-important operation, in those cases where it may be essential to the success or safety of any ship or ships in the Navy, or any expedition they may be engaged in."

Discussion of Lieutenant Bell's Plan.—The discussion that followed was very severe, for as it will be observed, there were no means provided for maintaining a uniform tension on this elevated and suspended wire, and if the vessels so rigged were pitching ever so little, one of the following events would occur, and probably both after a short time. By the ships pitching toward each other, the coal bags would be likely to be dropped into the sea, while by pitching away from each other the foremast of the collier would be unshipped or the suspended cable snapped. Commodore Campbell said: "I do not agree with him, but I admire his principle, and I sincerely hope that this paper will help to give another blow to the happy-go-lucky system, and assist us in bringing about that systematic organisation of every detail for which the Navy is now crying out with one voice, and which is now happily receiving the special attention of our rulers." Lieutenant Tupper said, amongst other things: "I think the practice of coaling ships at sea ought to be made just as much a drill and evolution as are many other operations which have to be performed." The chairman of the meeting, Admiral Boys, said in relation to Bell's plan: "But if these ships should get in any seaway whatever, the operation, I believe, must break down."

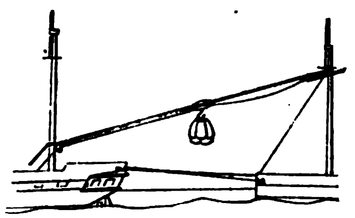


Fig. 249. Diagram showing Bell's Plan for Coaling at Sea.

Lieutenant Tupper's Plan.—Lieutenant R. G. O. Tupper, R.N., submitted a different plan for coaling vessels at sea, as shown in Fig. 250.

His plan provided an endless rope, starting from the stern of the collier in tow of the warship, passing over an elevated support on the foreyard, and thence to the aftermast of the warship. This endless rope was to have buckets of coal secured to it at frequent intervals, and the whole was to be operated by a capstan, the coal being thus passed from one ship to another. This plan was of course subjected to the same criticisms as that of Lieutenant Bell, namely, that in any seaway whatsoever the cable would either be dropped into the sea by excessive slack or snapped by pitching in the reverse direction.

The Low Plan.—The Hon. Phillip B. Low secured a patent, 10th July 1893, on a plan practically the same as that Lieutenant Bell described in his paper six years earlier, but with the important addition of a counterweight secured to the end of an elevated carrying cable, Fig. 251.

This counterweight was so arranged as to maintain a constant tension, on the

suspended cable, regardless of the motion of the ships. The use of a counterweight to maintain a constant tension on a suspended wire rope would be successful in any stationary plant on shore. His plan was tested by the United States Navy Department in October 1893. The test took place on board the U.S.S. "San Francisco" and the U.S.S. "Kearsarge." The distance from the shears of the cruisers to the upright poles on the colliers was about 235 feet, hence the distance between the vessels was somewhat less than 200 feet. The transmission wire, as the inventor called it, was secured to the deck of the "San Francisco," supported by a pair of shear-poles at the stern, then run on an incline to a gin pole at an elevation of about 32 feet above the foremast of the "Kearsarge," which played the part of the collier, and so gave a gradient of about 8 degrees to the horizontal between the rope terminals and the vessels. After the cable was threaded through the gin block it was bent backwards, while to the end was secured a counterweight of about 1,600 lbs. The bags of coal weighed nearly 200 lbs., and the time required to travel from the pole-head on the collier was about fourteen seconds. To hoist and send over ten bags of coal occupied some twenty minutes, giving about the rate of $2\frac{2}{3}$ tons per hour. The Board of Naval Officers were instructed to report on the trial, and their official report was that in rough weather the apparatus would not be of the slightest use in transferring coal from one vessel to another. The apparatus was reported to have

Fig. 250. Diagram showing Lieutenant Tupper's Plan for Coaling at Sea.

Fig. 251. Low's Plan for Coaling at Sea.

worked well; but as the sea was calm, it was impossible to say what would have been the result in a moderate sea. As the sea became heavier, the distance between the ships would have to be increased for safety, and there would have to be a corresponding increase in the height of the gin-block in order to give a proper inclination to the connecting rope. Presuming that the distance between ships was increased 300 feet, the same angle of inclination preserved, and the same height of shear-poles on the warship, then the gin-block on the collier would have to be 70 feet above the deck of that craft, as this would reach to the truck of the foremast of the collier. It is clear that to attempt to attach bags of coal at such a height would be difficult, if not altogether impracticable, especially in a rolling sea. Even then the capacity, whatever it might have been at 200 feet, must be something less at 300 feet distance between the ships. In order, therefore, to increase the capacity of this device, it would be necessary to increase the load; but as it will be noticed that with a 200 lb. load a 1,600 lb. counterweight was employed, a 400 lb. load would require a 3,200 lb. counterweight, while a 600 lb. load would require a 4,800 lb. counterweight, and so on. The element of danger to the ship in carrying any such counterweight would seem to need consideration. If the tow-line should snap, this weight would be pulled up to the gin-block, and as something would then give way, the dropping counterweight would do great damage.

The John E. Walsh Plan.—Fig. 252 illustrates a plan patented by John E. Walsh,

of New York. The cable R, attached at one end to the towing boat, inclines upwards and bends over a pulley block O, near the head of the foremast, thence bends under the pulley block O, carrying a counterweight W. The rope is bent many times, and must therefore carry a very large counterweight to sustain the requisite tension in the rope R. The objections which have been offered to Low's inclined cable and counterweight apply equally well to the Walsh plan.

The illustration also shows overhead derricks for hoisting the load out of both hatches to platforms on the masts, the platform on the mainmast being somewhat higher than that on the foremast, and an auxiliary inclined cable between the masts adapted to carry the coal forward.

Spencer Miller, the author of "Coaling Vessels at Sea," maintains that any hoisting device of this class elevated to any height will be impracticable in a rolling sea. If the load is to be hoisted at all on ships at sea, it should certainly be steadied between guides.

Lieutenant Niblack's Paper.—Lieutenant A. P. Niblack, in a paper on "Coal Bunkers and Coaling Ships," read before the American Society of Naval Architects and Marine Engineers in 1893, presented a most complete argument for the necessity of rapid coaling as a factor in efficiency, giving full data respecting the speed with which

Fig. 252. Diagram showing the Walsh Plan for Coaling at Sea.

the ships then built in the United States could be coaled in harbour. He says: "Our crack ship, the 'San Francisco,' could only take in coal at Sandy Point at the rate of 10 tons per hour, and ordinarily she takes three days, working hard, to fill up. Efficiency in ship's crew must also be supplemented by the best mechanical arrangements practicable, and the coal must be able to go anywhere and to stay there." Coal supply and rapid coaling are in his view most important factors in efficiency, not only in emergency, but also in times of peace, as the time spent in coaling ship is time wasted. He proceeds to give figures representing the average of three or more good actual performances of each ship, and shows that the "Chicago," the "Charlestown," and the "Newark" coaled at the rate of 30 tons per hour. He quotes from the British manœuvres, giving the average of the "Thunderer" at 17½ tons, and of the "Anson" at 51·6 tons per hour, the latter using the Temperley transporter.

The first test by the British Admiralty in coaling at sea took place in the middle of August 1890, some 500 miles south of the Azores, and 1,000 miles or more from the African coast, with 2,000 fathoms water under the ships' bottoms. Thus all the conditions of being at sea were amply fulfilled.

The ships that coaled were the "Ajax," "Camperdown," "Audacious," "Iron Duke," "Northampton," "Immortalité," "Aurora," "Neptune," "Conqueror," and "Minotaur." They took varying amounts—in all cases the minimum necessary to take them back to

Torbay, some 1,800 miles distant. One ship, the "Howe," evaded coaling, and had to go into Vigo. The rest, although their captains protested strongly in several cases, took coal. There were three full colliers with the fleet, and each ship took an average of 350 tons, at the usual harbour rate, or nearly so. The sea was smooth to look at, but there was a heavy Atlantic swell. Each collier was lashed alongside a battleship, with thick fenders between. Towards the end of the operation the swell increased, and a considerable amount of "moral suasion" was required with at least one collier captain. The coal was taken in in derricks at the main deck ports. One or two ships had torpedo beams broken, and one collier sustained some dents in her side; but no material damage was done. The ships were kept bows on to the swell, and so there was no rolling. All, however, pitched somewhat, and the colliers when they began to get light pitched rather violently. It was this pitching which did such damage as was sustained.

British ships coaling in harbour, where they were completely surrounded by colliers, and working Temperley transporters and whips combined, have coaled 150 tons per hour.

Difficulties of Coaling at Sea during the Spanish-American War in 1898.—Mr Spencer Miller quotes some paragraphs which appeared in the daily press while the conflict was being waged. The *Commercial Advertiser* published on 26th June 1898 the diary of their correspondent, who was on board the United States battleship "Iowa," but only that part is quoted which has reference to the coaling problem.

"June 7, 1898. . . . The collier 'Justine' is alongside, and we started in coaling. The 'Justine' has not the coaling capacity of the 'Merrimac,' but she is a fine steamer, very strongly built. In a seaway this is a great advantage, for though we gave her some pretty hard knocks, no holes were punched in her sides. Since she comes right alongside of our harbour belt, she can be the only sufferer. She is also very convenient to coal from. Working three forward hatches we were able to take aboard very easily 260 tons before supper-time.

"June 8, 1898. . . . Much to our disappointment we find that we cannot get the 'Justine' again to-day, as she was ordered over to the 'Brooklyn,' and we had to content ourselves with the 'Sterling,' to our sorrow. We had every fender out possible, big rope fellows too, that will stand any amount of knocking, but no sooner had the 'Sterling' come alongside than she came up heavily against the side of our ash chute and opened a hole in her side. There was nothing to do but send the carpenter's gang aboard and shove her off for repairs. Every-one is disgusted with the 'Sterling' for having sides like paper.

"June 11, 1898. . . . We tried to coal again from the 'Justine' to-day. Made all preparations, and even started sending the coal aboard; but before we got more than a dozen bags on, the ships knocked together again so badly that we had to cast the collier off and give it up again. It is most aggravating, for now we must clean up the ship, only to start in coaling again on Monday."

Thus it will be seen that while coaling was begun on the 7th, yet on the 8th, 9th, 10th, and 11th practically no coaling was accomplished, although each and every day the ships needed coal, and it was most important that they should have it. It may be interesting to know that this same collier "Justine," after discharging a single cargo of coal, was returned to Newport News and laid up a long time for repairs, the bill for which exceeded £200.

It is commonly believed that Admiral Cervera's defeat was directly due to his being short of coal and provisions, which brought him into the harbour of Santiago de Cuba to fill his bunkers. But had he been speedy in coaling after he arrived there, he probably could have escaped from the harbour, because the American vessels were also short

of coal, as will appear from the messages exchanged between Admiral Sampson and Commodore Schley and the Navy Department, as they appeared in the report of Captain Crowninshield, Chief of the Bureau of Navigation. The following message was sent from Commodore Schley to Admiral Sampson: "Arrived 21st May off Cienfuegos. . . . Expect difficulty here will be to coal from colliers in constant heavy swell. Other problem easy compared with this one so far from the base." On the same day Admiral Sampson received this despatch from Commodore Schley, dated 24th May: "Coaling off Cienfuegos is very uncertain. Having ascertained that the Spanish fleet is not here, I will move eastward to-morrow, communicating with you from Nicholas Mole. On account of short coal supply in ships, cannot blockade them if in Santiago. I shall proceed to-morrow, 25th, for Santiago, being embarrassed, however, by 'Texas'' short coal supply, and her inability to coal in open sea. I shall not be able to remain off that port owing to the generally short coal supply of squadron, so will proceed in the vicinity of Nicholas Mole, where the water is smooth, and I can coal 'Texas' and other ships with what coal may remain in collier." So much has been said on this subject that it is only necessary to remark that had Commodore Schley been in possession of colliers fitted for coaling at sea, especially during his journey from Cienfuegos to Santiago, there would have been no occasion for his leaving Santiago unguarded a day after his arrival.

French Experiments.—While the Spanish-American War was in progress the French were making experiments in this problem of coaling at sea. The Paris correspondent of the *Times* wrote on 28th July 1898, in reference to the coaling with the Temperley transporter, as follows:—

"An interesting point in these manœuvres has been the attempt to coal at sea. The collier is lashed to the ship, and the ship then steams ahead. A speed of 10 knots is said to have been reached, but other information points to a lower speed by some knots.

"The 'Japon,' a collier, 3,000 tons, furnished with a Temperley transporter, while steaming 6 knots in a rough sea and strong breeze, succeeded in coaling the 'Marceau' and 'La Touche Treville' with 200 tons of coal. It was a successful beginning, but the operation was not continued so long as desired, it being interrupted in the case of the 'Marceau' by way of precaution, and in the case of 'La Touche Treville' on account of an accident to the 'Japon,' which had to return to Toulon for repairs. This problem does not seem to have been fully solved, as proved by the damage sustained by the 'Japon.' The French Admiralty is confident of a decisive result, for it has just decided that the 'Japon' is to remain permanently attached to the Mediterranean reserve squadron.

"Coaling and revictualling in motion is the question now before all the great navies, and as such experiments cannot be made in the dark, it is certain that all nations will almost simultaneously have the necessary apparatus for coaling ships to be supplied at sea, so that they can be sent to the greatest distance without running short, at the moment of combat, of either food or coal."

Coal Supply.—The Spanish-American War and its lessons furnished the naval officers of foreign powers with points of interest. For instance, a paper on coal supply was written by the late Vice-Admiral P. H. Colomb, R.N., entitled "Coal Supply, Speed, Guns, and Torpedoes in Naval Marine War." * As regards coal supply, Vice-Admiral Colomb said: "We get speed and certainty for voyages made under steam, and the full advantages are reaped in peace time, because coal supply can be exactly arranged for

* This paper appeared in *Cassier's Magazine*, August 1898.

and calculated according to the work required of it, for that can be known; but for the warships in war no such special arrangements and calculations are possible. Coal supply can be treated only generally before the war breaks out. No one can say beforehand whether it has been advantageously or economically allotted."

A plan was devised in 1893 by Mr Spencer Miller of stretching an elevated cable from the stern of the warship to the bow of the collier in tow, one end to be securely fastened to the warship and the other end wound round a compensating engine, similar to the steam towing machines. The load running on this cable was to be conveyed by an endless rope. It was expected that the compensating engine would keep an equal strain on this elevated line irrespective of the pitch of the vessels so connected. In March 1898, Lieutenant J. J. Woodward, Naval Constructor, stationed at Newport

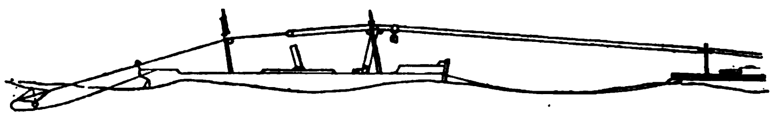


Fig. 253. Plan of American Woodward Coaling at Sea.

News, Va., invited plans and prices for a device embodying much the same general ideas. A few weeks later, in April, a plan was sent to Mr Woodward, and he in turn transmitted it, with favourable recommendations, through the Chief Constructor, to the Secretary of the Navy. It was not, however, until August of the same year that any understanding was arrived at with the Navy Department whereby the work of construction could be begun. The plan, considerably modified, was submitted to a Board of Naval Officers, consisting of Rear-Admiral Ramsay, President, Mr Thomas Williamson, Chief Engineer, and Commander J. L. Tanner. They considered the device "feasible in moderate weather." Thereupon the Department contracted with the Lidgerwood Manufacturing Co., of New York City, U.S.A., to have the apparatus installed on

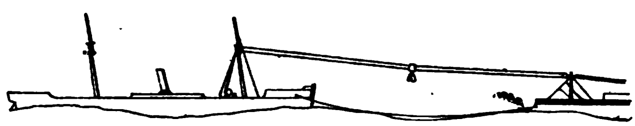


Fig. 254. General Arrangement of Spencer Miller's Plan for Coaling at Sea.

board the collier "Marcellus." So much time, however, was lost in negotiations, that before the work of construction was begun, the war had come to an end.

On 15th October 1898, experiments were performed in New York Harbour with a tug, towing a sloop, using a quarter-sized model. Shear-poles were mounted on the tug, and blocks on the mast of the sloop, the distance between points of support being 100 feet. An endless rope was employed, being used in accordance with the sketch shown in Fig. 253.

The experiment was performed in a storm, which was so severe that the sloop shipped water over the bow, and both boats rolled and pitched very badly. In spite of this, however, the bags of coal were conveyed across the space as though the sea were smooth, the sheet anchor serving efficiently as a compensator, and maintaining a perfect tension on the endless conveying cable. The principle of the "Miller" conveyor, as used on the U.S.S. "Marcellus," is shown in Figs. 254 and 255. But when tested at sea it actually had an additional rope above the conveying ropes which was led

astern terminating in a sheet anchor. This device is now called the Marine Cableway. It is intended to be utilised by ships stationed at a distance of from 350 to 500 feet apart. It might possibly work successfully at a greater distance, but such an experiment has not yet been tried. The vessels are connected by an ordinary cable, and the towing vessel gets under weigh at a speed ranging from 4 to 8 knots per hour, according to the condition of the weather and the sea which is running. A speed of 5 knots in moderately rough water has been found sufficient to keep the cableway taut and to maintain the proper distance between the craft, unless a tide or some unusual current is encountered.

The appliance which has been fitted to the "Marcellus" may be described as follows:—

An engine, with double cylinders and double friction drums of special design, is placed just abaft the foremast of the collier. It has two steam cylinders 12 by 12 inches. A $\frac{3}{4}$-inch diameter steel rope is led from one drum over a pulley at the mast-head, and thence to a pulley at the head of shear-poles on the warship, and returned to the other drum.

The engine moves in the same direction all the time, and tends to wind in both strands of the conveying rope. A novel form of load carriage is suspended from this rope. It is provided with a grip on the upper strand and wheels to run on the lower strand. This carriage conveys two loaded bags, weighing 420 lbs. each, suspended from a bail, which hangs in a hook below the carriage. A hoist takes the bags from the deck, lifting them to the mast-head, while the conveyor carriage, coming in from the mast-head, locks itself under the bail. As soon as the bail is released by a man under the trestle-trees, the engine operator hauls in the lower parts of the conveyor line. The upper part of the conveyor line is therefore drawn from the rear drum, slipping the specially contrived friction devices. Thus the carriage passes from collier to ship, the tension being sufficient to ensure the bags clearing the water between the vessels. The rope is drawn in at a speed of 1,000 feet per minute, and if the points of support—mast-head and shear-head—do not vary, the upper strand will be drawn out, under tension of about 3,000 feet, at the same rate of speed. If, however, the distance is increased during the transit of the load, the extra rope called for is given by the slipping of the upper part from the drum. This increases the speed of the upper strand. On the other hand, if the ships reduce the distance between points of support, the speed of the upper strand is reduced.

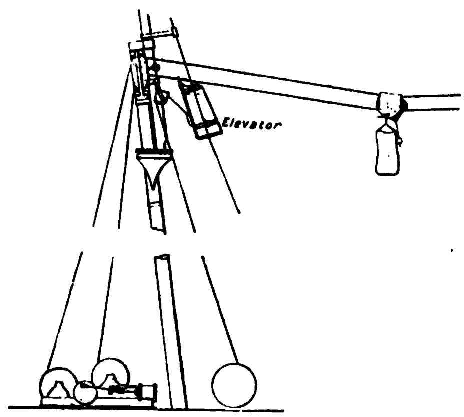


Fig. 255. Details of Spencer Miller's Plan for Coaling at Sea.

When the carriage reaches the pulley at the shear-head, it collides with it—at reduced speed—and thus striking, releases the lower hook, and the two bags and their bail drop into the canvas shoot and slide to the deck of the warship. Loads drop in this manner at the rate of one per minute. The empty carriage is drawn back by the rear drum, the forward drum being thrown partially out of friction.

An auxiliary $\frac{3}{4}$ in. rope, known as the sea-anchor line, is stretched above the two strands of the conveyor line, and under a pulley on the carriage. This rope is attached by a "knock-off hook" to the superstructure of the vessel, and rests in a "saddle" on the

shear-head, whence it leads through the carriage over pulleys at the head of the foremast and mainmast of the collier, and runs on astern several hundred feet into the sea.

To the end of this rope a drag or sea-anchor is attached, made of canvas in the form of a cone. This sea-anchor is selected in reference to the speed at which the ships are to travel. In a smooth-water test, speeding at 6 knots, a drag 7 feet in diameter at the base was used. During the rough-weather trial, the same anchor seemed to give the required tension at 5 knots.

The sea-anchor line is to support the carriage, when empty, on its return to the collier. It permits the conveyor line to be slack, and prevents the overturning or twisting of the carriage. Doubtless at times it helps also to support the load in transit across, but instantaneous photographs taken during the transit of the load show the sea-anchor line slack, thus demonstrating that the tension device on the conveyor line is sufficient to keep the load above the water during transit.

The tests which were made by a Board of United States Naval Officers showed that from 20 to 25 tons of coal per hour could be delivered from the collier to the vessel even when a moderate gale was blowing. The towing vessel, which in this instance was a United States battleship, consumed from 3 to 4 tons of coal per hour. Consequently the amount actually received into the bunkers ranged from 16 to 20 tons, which would be an average of 375 tons in twenty-four hours. It is claimed that such a low speed would not be necessary in regular service, and that the vessels might proceed at a speed

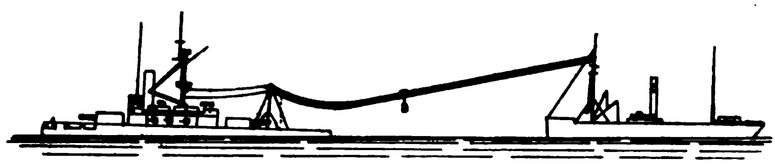


Fig. 256. Diagram showing the Temperley Miller Plan for Coaling at Sea.

of from 8 to 10 knots an hour if desired. However, the consumption of coal on the towing vessel would be largely increased unless the collier could proceed under her own steam. There is a danger, however, that the proper distance to be maintained might then be lessened, whereupon the cable would sag, and thus cause a cessation of operations.

While one of the principal advantages claimed for the system is that a battleship or merchant liner can take coal on a voyage without the necessity of entering the harbour, thus saving time, the process of transferring fuel can also be thus carried out with a minimum of hand labour. One man is required at the hoisting engine, which is very similar to the steam winch now used for transferring cargo on board the large merchant steamships. A squad of twenty men is required in the hold of the collier to fill the bags and deliver them to the deck, while another squad of from fifteen to twenty transfer the bags to the lift. But one man is ordinarily required to do the overhead work, and he is stationed in the trestle-trees of the collier; but for greater safety, two men are employed when the weather is rough and the ship is pitching heavily. The only hands who are required on the receiving ship are stationed at the top of the platform or shear-head to empty the bags into a canvas shoot and return them. There is of course a force of bunker trimmers in the hold. In coaling the battleship, it was found that the loads could be transferred at the rate of one a minute without great difficulty, although the rate of loading was somewhat slower, the average being 3 or 4 tons per hour less.

The experiments which were conducted by the American Navy with this system aroused such interest that a number of American shipowners are considering the idea of utilising the apparatus for supplying coal to liners at such points in harbours where the water is too shallow to admit of placing the fuel on board their ships when loaded by the usual methods. It is understood that further official trials are to be made with a view to supplying victuals as well as the necessary coal supplies while at sea.

The matter was then taken up in England by the Temperley Transporter Co., who, in co-operation with Spencer Miller, and without changing the original idea, have paid great attention to the details of the scheme, making various improvements with undoubted success.

Fig. 257. U.S.S. "Illinois" receiving Coal from the Collier "Sterling."

The appended diagram, Fig. 256, serves to illustrate the general principle involved. The collier is in tow of the battleship, being drawn by two hawsers, which are secured along the stern and to the collier well back from the bow.

There is every reason to believe that this apparatus will be an ultimate success, provided that the coal can be conveyed in sufficient quantities, which appears now to be the only difficulty, although portions of the apparatus are still in the experimental stage.

The principle of coaling at sea under weigh can hardly be considered as established by the comparatively few experiments already made. It is to be tried off and on for a year or so with various battleships and cruisers, but the final official adoption of the scheme may, however, be considered certain with the above proviso, because of the strategical advantages involved.

The difficulties which have been mentioned bear out Lieutenant Bell's misgivings as to coaling from broadside. It is, however, not unlikely that with adequate means to keep the ships apart, broadside coaling will be neither impossible nor impracticable. One of the latest schemes brought forward is that of Mr A. C. Cunningham, Civil Engineer in the United States Navy, and Mr William Seaton, of the C. W. Hunt Co., of New York City, by means of which it is alleged that broadside coaling from ship to collier can be effected with impunity. The vessels are kept apart by a current of water pumped from one ship against the other either by special pumps, or by the use of

Fig. 256. "Retvizan" receiving Coal from the Cruiser "Asia."

existing bilge pumps. The lashings will be kept taut by means of water jets which are the equivalent of elastic struts. These jets take the place of the fenders, which were, owing to their unsatisfactory work, the cause of the abandonment of broadside coaling. Any breakdown to the pump or pumps might, however, prove fatal to the success of this scheme.

Fig. 257 represents the Spencer Miller marine cableway, as used for coaling vessels at sea, and shows the U.S. battleship "Illinois" receiving coal from the collier "Sterling"; in this instance the operating winches are placed upon the battleship.

Fig. 258 shows the adaptation of the Spencer Miller method of coaling ships at sea as used by the Lidgerwood Manufacturing Co. The Russian battleship "Retvizan"* is here shown receiving coal from the cruiser "Asia" in the Baltic Sea. The "Retvizan" is equipped with a marine cableway operated by electric winches. This equipment was put on after the ship was constructed. The electric winches built are of limited power, owing to want of space, and it is not contemplated to handle more than ½ ton of coal at a time. After the tests were completed, Captain Stchensnovitch, commanding the "Retvizan," in a letter of congratulation to Mr Spencer Miller, the inventor, wrote as follows:—"Witnessing this last success, I am sure that your system of coaling at sea will be adopted by all the navies of the world. . . . The Trial Board reached the conclusion that the marine cableway works very satisfactorily, and is well worth adoption for general use on board war vessels."

During the Russia-Japanese War ten of the largest battleships and cruisers of the Baltic Fleet were fitted with marine cableways similar to that installed upon the "Retvizan." These will enable the Fleet to coal at sea should they attempt to make the journey to the Far East. These cableways permit the ships to be 300 feet apart in a smooth sea, and 800 feet apart in a rough sea; at this distance, however, the loads have to be reduced to half-a-ton.

* This is the ship so heavily torpedoed during the Russian and Japanese War, and finally sunk at Port Arthur, December 1904.

UNLOADING AND LOADING APPLIANCES.

CHAPTER XVII.

DISCHARGING BY MEANS OF SKIPS AND GRABS.

BOATS and barges as well as railway trucks usually deliver material at the point where the mechanical appliances for its further conveyance are fixed, and here the transfer has to take place. Hand labour at this point is out of the question if labour-saving appliances can do the work wholly or even partially. This part of the subject may be divided under two heads; *i.e.*—

A. Appliances for discharging ships or barges.

B. The discharging of railway trucks.

A may again be subdivided under three heads—

1. Discharging by skips or grabs.
2. Discharging by means of elevators.
3. Discharging by means of self-emptying boats and barges.

1. DISCHARGING VESSELS AND BARGES BY MEANS OF SKIPS OR GRABS.

To operate any kind of bucket for unloading purposes a crane of some description is necessary. Cranes are often fixtures on the quay-side. When large vessels have to be discharged they are used in pairs and in even greater numbers. Not infrequently they are mounted on rails so as to be readily moved to any point on the quay at which the boat to be unloaded may most conveniently be moored.

It is not, however, so much the object of this chapter to give a technical description of cranes, as to describe in detail such skips or grabs as are manipulated by cranes. High-level cranes, which are largely used, but perhaps more for unloading on to stock piles than on to conveyors, are generally described in a separate chapter.

The oldest form of skip or grab consists of a large bucket suspended slightly below its centre of gravity by an arched bail with a catch, which keeps the bucket in an upright position. Such buckets have a capacity of from 1 to 3 cubic yards, and are lowered into the boat and there filled by hand. When full, they are raised by the crane and swung into an unloading position, when the catch being withdrawn, the buckets tilt and discharge their contents, this process being repeated as often as desired. This mode of unloading is used for grain as well as for minerals, but has to a great extent been superseded by the self-filling skip or grab, as the latter dispenses with hand labour in filling.

Grabs are frequently used for excavating purposes, perhaps as much so as for handling grain or coal. They are probably of great antiquity; although the earliest grab known only dates from 1703, there is every reason for believing that appliances of this type were in use at an earlier period. In 1703 the French Academy of Science approved of the design of a machine for excavating purposes, a description of which was published by them. This appliance was the invention of a M. Gouffe, and had the outward

appearance of the modern grab. It was provided with serrated edges that cut into the ground, and was operated by two ropes and a bar which gave the cutting edges a downward pressure. The two ropes were manipulated by two windlasses. There are other designs too numerous to mention which have from time to time sprung up, only to disappear again. The grab of to-day is perhaps one of the most familiar of modern labour-saving appliances.

Before passing to a more minute description of grabs, one or two types of mechanical buckets may be mentioned, one of which is illustrated in Fig. 259. These generally consisted of a large tub with a hinged bottom. Such appliances were used at the Millwall Docks for unloading grain before the Duckham pneumatic elevator came into use. These tubs have the advantage of being light. They hold 60 bushels of grain, or nearly 3 cubic yards, and weigh only 5 cwts. The bottom is divided into two halves which are hinged to an iron bar traversing the bottom of the tub. The lower edge is so contracted as to form a truncated cone 6 inches in height. Thus the diameter of the lower portion is 1 foot less than that of the main portion of the tub.

The lower rim is so machined as to fit the hinged bottom. The bucket is suspended by a length of $3\frac{1}{2}$-inch wrought-iron tubing passing through the bearing B, and having a suspending eye at the top and an attachment C for four connecting rods D at the lower end. When suspended from the eye the bottom door supports the shell portion of the tub. When filled, the tub is lifted by the crane and deposited on a circular opening in the top of the receptacle where the grain, &c., is to be discharged, and as the crane continues to lower, after the shell of the tub has reached its seat, the doors open (as shown in dotted lines) and the grain discharges. The doors shut automatically as soon as the crane lifts the empty bucket off its seat.

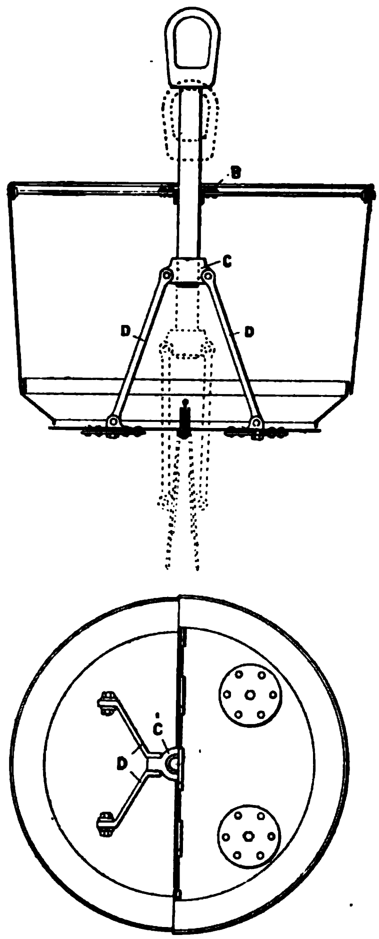


Fig. 259. Mechanical Bucket formerly in use at the Millwall Docks.

The self-discharging skip of Messrs Taylor & Hubbard, of Leicester, is similar to this appliance, as will be seen by Fig. 260. It must be filled by hand as is the previous one, but discharges its load automatically, after the manner of a single-chain grab to be described presently. The automatic gear A which is suspended from the jib-head of any ordinary crane, works automatically at any predetermined point to which the gear may have been raised or lowered. The mechanical working of this apparatus, which can be operated by one man, is clearly shown in Fig. 260.

The flaps forming the bottom of the skip are connected by links FF to the rod G which is attached to the lifting chain, while the body of the bucket has connected to it a sleeve H, through which the rod G passes, and which has a conical top with a shoulder H^2.

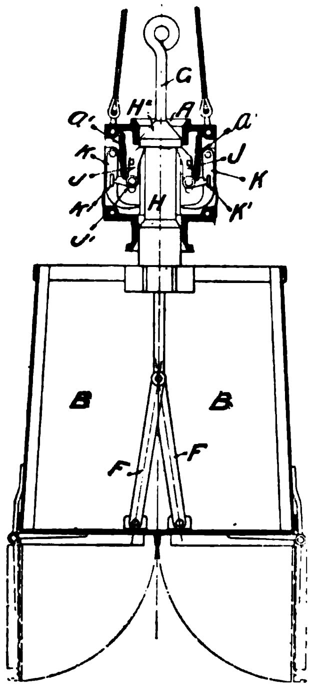


Fig. 260. Self-discharging Skip of Taylor & Hubbard's.

The automatic gear A is independent of the jib. Bell crank triggers J, adapted to engage the shoulder H^2, have projections J^1 sliding in slots in the sleeve A, and are normally pulled upwards as shown by springs A^1. Projections engaging slots in the part A limit the lateral play of the triggers J. In operation, on raising the bucket after loading, the triggers J are forced apart by the conical end of the sleeve H, and then close under the shoulder H^2 as shown. On lowering, the weight of the bucket pushes the triggers down so that their horizontal arms engage projections K^1 on the arms K, which are forced inwards by springs, and on further paying out the chain, the bottom of the bucket opens. The bucket itself is supported by the triggers J. As in lifting, the weight of the bucket is again taken by the chain. The triggers turning on the fulcrums K^1 are pulled outwards by their springs, so that on again lowering, the sleeve H drops, and its shoulder H^2 engages the arms K, releasing the triggers J, and allowing them to return to their normal position ready for the next operation.

An intermediate form between the skips just described and the grab, is illustrated in Fig. 261,* which shows the jaws in an open and in a closed position. This appliance is used for a variety of purposes—for unloading minerals and grain for instance—in which case the receptacle is filled by hand, and then swung by means of the crane into position so as to deliver to the spot at which the discharge is required, when the contents can generally be deposited by means of the two outer chains.

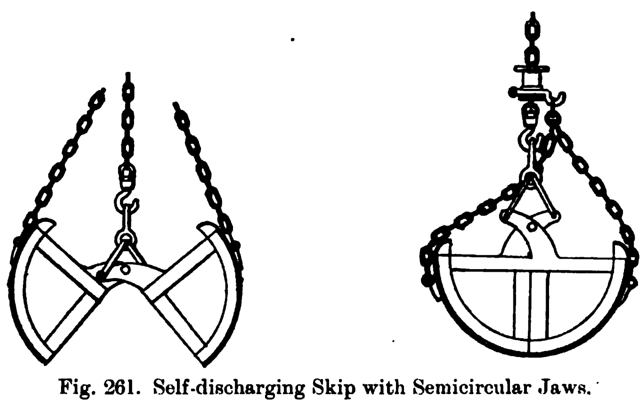


Fig. 261. Self-discharging Skip with Semicircular Jaws.

It will be readily seen that the discharge of coal from this appliance is more gentle than from the skip previously described.

Salomon's Experiments with Grabs on Dry Sand.†—A series of observa-

* See Magazine of the Thames Iron-works, June 1900.

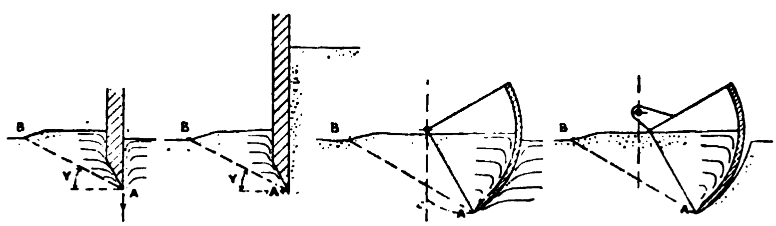
† See Dingler's *Polytechnisches Journal*, 2nd May 1903, pages 283 and 284.

tions have been made by Mr B. Salomon, the results of which were published in the *Zeitschrift des Vereines deutscher Ingenieure* in 1886.

He found that the resistance of the grab as dug into sand increased with the depth to which the grab penetrated, and he maintained that his experiments taught him that this increased resistance is also essentially dependent upon the shape of the grab jaws, or rather on the position of the fulcrum to the radius of the curve of the jaw.

Perhaps the simplest way in which to explain the results of these experiments is to imagine a flat, very thin, and perfectly smooth spade dug into sand in the direction of its plane. In that case the only resistance caused will be to the progress of the cutting edge of the spade, that is to say, to its cutting action, because the grains of sand lying directly in the path of the blade are pushed to one side.

But suppose the blade of the spade to be thicker and somewhat curved, like the jaws of a grab, then it will displace a certain amount of sand which must be pushed aside in proportion to the depth of the curve. In such a case the sand will either be compressed, or, if the blade does not enter a great depth, the sand displaced will be pushed outwards on the oblique side of the spade in the direction of the line AB (see A, Fig. 262).



Figs. 262. Diagrams showing Action of Grab.

According to the resistance of the sand the line AB forms an angle Y with the horizontal. The angle $Y = 45$ degrees, assuming $\frac{X}{2}$ to be the natural angle of repose of the material.

The resistance thus set up increases very considerably should the surface of the spade or jaw be rough, and, as shown in A, Fig. 262, the sand is heaped up as the spade enters the ground, and thereby displaces the sand by its own body.

A similar resistance is felt on the other side of the blade, to which must be added the friction between the blade and the sand.

So far it has been assumed that the sand was level on either side of the blade, and that the blade entered vertically, as shown in A, Fig. 262 ; but if B, Fig. 262, is accepted as a truer picture of what actually takes place, namely, that the sand is heaped up much higher on the right or interior side of the grab, then it is obvious that the resistance is greater on the right side.

According to Mr Salomon, the total amount of resistance can be considerably lessened by a judicious shaping of the digging blade. A grab with cylindrically shaped jaws was therefore chosen, the axis of rotation coinciding with its radius (see C, Fig. 262). Even with this there will be a considerable amount of resistance on the outer walls of the blade, because the material lying below cannot escape, but must be compressed. Salomon found that when the axis of rotation was placed slightly above the centre of the

radius of the blade, as in D, Fig. 262, the outer resistance was diminished, and the internal digging power of the jaws increased.

The sum total of these experiments, although of small practical value, point to the advisability of slightly raising the axis of rotation of the jaws.

It was, however, judiciously pointed out by Baron Hanffstengel that in these experiments the point of rotation was fixed, and that on that account a fairly great pressure between the sand and the grab jaws could be set up, whereas in practice the total vertical pressure cannot at the most exceed the weight of the grab with its contents, and will probably be less, as a portion of the weight is held by a chain.

Mr Salomon says that the higher the point of rotation is removed from the centre, the greater the power necessary to raise a given quantity, on account of the compression of the material between the two jaws of the grab, as may easily be understood from Fig. 263. No doubt the amount of matter scooped up increases in proportion as the gripping point is raised, but the difficulty of closing the jaws is proportionately increased.

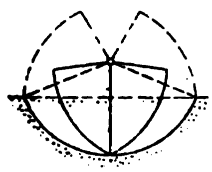


Fig. 263.

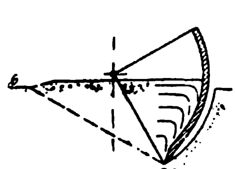


Fig. 264.

Instead of shifting the action of rotation in this way it would in many cases be more advantageous to form the cutting edge of the blade in a straight line instead of a curve, as shown in Fig. 264, as in such a case the blade will penetrate into the material better at the first onset.

If the weight of the grab be insufficient, the jaws will have a tendency in closing to lift themselves out of the material after having sunk to some depth, while the cutting edge of the jaws will describe instead of an arc a curve as shown in the dotted lines AC, Fig. 262 C, and in consequence the grab will not take its full load.

The illustrations give a clear representation of the movement of the jaws of ordinary grabs hinged at or near their centre, but what has been said does not refer to grabs which are hinged from their haunches. In that case the action is different altogether, as the filling of the grab does not depend in the first instance upon the jaws entering the material to some depth through the drop of the grab from a certain height, but depends entirely on a scraping action which will be understood from Figs. 265 and 266, the latter showing not only the scraping but also the closing action of the toggle levers.

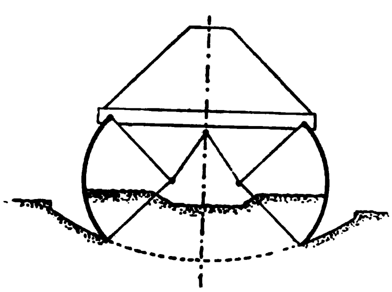


Fig. 265.

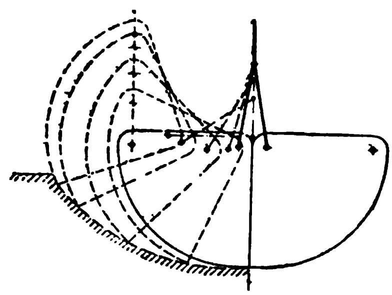


Fig. 266.

The Priestman Grab.—The Priestman grab was the first placed on the market in this country. It is operated by double chains from the crane engine. There are now in use many different designs with double and also with single chains.

A form of the Priestman two-chain grab is illustrated in Fig. 267. AB represent the two chains which manipulate it.

This grab consists of a substantial frame of angle iron, to the lower end of which the two semicircular jaws CC are hinged, the jaws themselves being provided with steel edges. Above the jaws CC is a spindle D fixed to the framework upon which the drum E revolves, and to which the cable A is attached, which chain leads to the winding drum of the crane. Chain B is attached to a second spindle F, the ends of which can slide up and down in the slot provided for them in the framework. The grab works in the following manner:—As soon as the chains are released, the open grab descends by its own weight into the material to be raised. In this open position of CC a portion of the chain A is wound on the drum E, and as the attendant shortens the chain A by means of

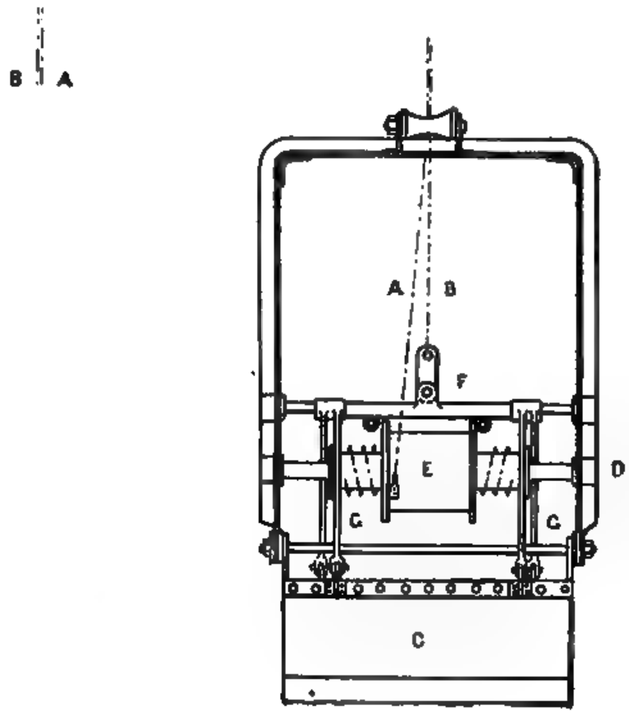


Fig. 267. Priestman Two-chain Grab.

the crane it unwinds itself from drum E of the grab, and this unwinding causes the winding up of the two short chains on the two smaller drums cast together on either side with the drum E. As the other ends of the two short chains are secured to the movable spindle F, these chains pull down the spindle into the position shown in full lines in Fig. 267, whereby the jaws of the grab are forced together by the levers GG and enclose their contents. The dotted lines in the end view show the spindle F in its highest position, in which the jaws of the grab are open. If chain A is further shortened the grab rises with its load, which can be released after it has arrived at the point of discharge by shortening chain B. This has the effect of opening the jaws and of causing chain A to wind itself upon the drum E. If the weight of the grab is on chain A it is closed, whilst if on chain B it is open.

The jaws rotate on a common pivot at their middle, and when closed represent a

practically semi-cylindrical receptacle dependent for the quantity elevated with each operation upon the depth of the initial penetration of the jaws into the material to be raised and by the weight of the falling grab, inasmuch as the grab is drawn upward at that moment away from the source of supply, when the jaws begin to close.

In the latest types the Priestman grabs have been simplified, chiefly by doing away with a portion of the framework. An up-to-date Priestman grab and crane are shown in Fig. 268.

These grabs are fitted with jaws of different types for handling various materials.

APPROXIMATE QUANTITY OF MATERIAL ONE MAN CAN RAISE WITH A PRIESTMAN GRAB PER DAY OF TEN HOURS AT AN AVERAGE DEPTH OF 20 FEET.

Capacity of Bucket or Grab in Cwts.	Tons of Mud.*	With Buckets.		With Grabs.	
		Grain in Quarters.	Small Coal, Shingle, &c., in Tons.	Coke in Tons.	Excavating, &c., in Tons.
3	100	—	—	—	—
5	175	—	—	—	—
10	250	1,200	200	125	150
20	500	2,400	400	200	300
30	650	3,200	550	275	400
40	800	4,000	700	350	500

These appliances are used for discharging grain, coal, and other heavy material as well as for dredging purposes. Generally speaking, mechanical details are identical; the cranes only differ in the way in which they are mounted according to the purposes they have to serve. Thus they may either be fixed on quay walls, or mounted on wheels, or installed in suitable barges, the latter being more often used for dredging purposes, as shown in Fig. 269.

Fig. 270 illustrates a very usual method of using grabs or cranes for unloading barges. The dotted lines show the position of the crane when depositing material into the hatchway, whence it is afterwards either loaded into railway waggons or disposed of by means of other conveyors.

The Hunt Grab.—Another type of a two-chain grab is the Hunt grab, illustrated in Fig. 271.

The principal difference between this and the Priestman grab lies herein, that whereas in the Priestman type the jaws are swivelled to the centre of the grab and closed from the outside, in the Hunt grab the jaws are swivelled at the haunches (Hone's patent) to an A-shaped frame, and are drawn together at the centre, which effects a rather more powerful closing action. Moreover, as the jaws open wider, they can take in a larger quantity of material at each lift. To operate this grab a crane gear with two drums is necessary. This is the case with all double-chain grabs. One chain is attached to the drum A on spindle B, and the other chain is fixed to the frame. If the first chain be released and the second chain held tight, the grab opens. The short chains are not attached to a second spindle as in the previous grab, but to the top of the framework, just as in the latest Priestman grab.

* When the deposit is plentiful and easily penetrated, the capacity of the grab is considerably more, up to 50 % under the most favourable circumstances.

The "Mohr & Federhaff" Grab.—A two-cable grab is built by Messrs Mohr & Federhaff, Mannheim, Germany, and is illustrated in Fig. 272. Its action is similar to that of the "Hunt" grab, with this exception, that the cables which close the jaws

Fig. 268. Example of Crane and Grab.

pass over three pulleys before being attached to the frame of the grab, so as to effect a still more powerful closing of the jaws.

In two-chain grabs the second cable or chain is not always wound on a second drum of

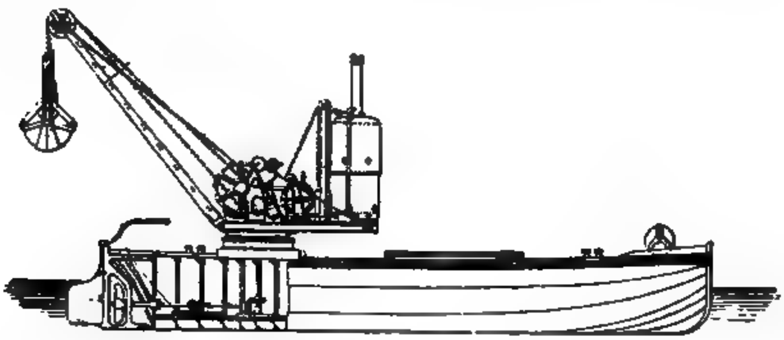


Fig. 269. Crane and Grab mounted on a Barge.

the crane, but is often held by an independent drum and brake in connection with a balance weight, a method devised by Messrs Priestman, which acts as follows:—

The cable which opens the grab is attached at the crane end to a drum which is loose on a spindle. Cast together with this drum is a second one of smaller diameter, from which a second cable leads over a guide pulley to a balance weight. This weight is held in position between two guides, generally behind the crane house, and is fitted

with a safety catch to prevent the weight from falling in case of a break of the rope. The loose drum is ordinarily provided with a band brake manipulated by a special lock

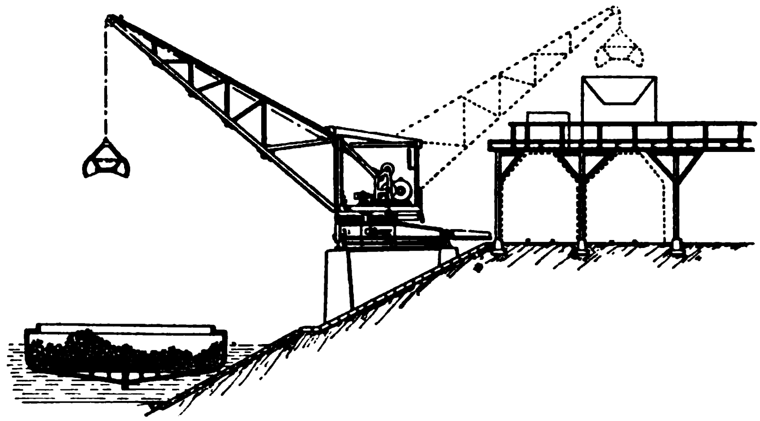


Fig. 270. Crane and Grab for Unloading Purposes.

lever. As the drum is thus held fast by the brake and the main cable lowered, the jaws of the grab are opened. By a slight modification, this apparatus may be made to act automatically. In this case the spindle is made to revolve by means of a chain connected to the main drum of the crane. On the spindle a thread is cut to which a nut is fitted, the latter being of an easy fit and so weighted as to prevent it from revolving with the spindle. Instead of that, it passes along the thread till a point is reached which forms an obstruction to its further progress, when it has to revolve with the spindle, which movement is used to throw the apparatus out of gear.

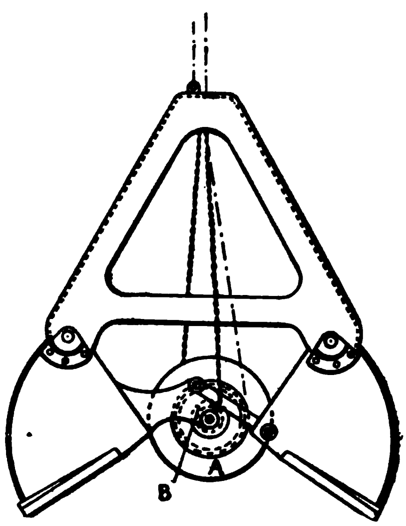


Fig. 271. Hunt Two-chain Grab.

The Jaeger Two-chain Grab.—The grab illustrated in Fig. 273 is built by J. Jaeger, of Duisburg, and is designed for an approximate capacity of $2\frac{1}{2}$ cubic yards. It will therefore handle about 2 tons of coal at a time. The framework which carries the jaws is of a triangular shape, built of angle iron with gusset plates, and stiffened with flat iron bars. The upper cross-bar consists of two channel irons. There is a second and movable cross-bar of similar construction, which is guided in its up-and-down motion on two iron bars of square section, marked AA. This movable cross-bar is connected by two pairs of toggle levers to the two jaws of the grab which are fixed to the point from which the radius of the jaw body is described. The jaws are hinged on the Hone principle, as may be seen from the drawing.

The chain which carries the load is divided into two before entering the grab. The action is therefore identical on either side, each chain being led over three

pulleys which are mounted between the two channel irons forming the fixed and movable cross-bars.

Fig. 274 shows several sections through the grab. It also shows the chain and the pulleys in the position in which the two cross-bars are close together, and in which the grab is therefore closed. The opening of the grab is effected by a steel rope which is attached to it slightly out of the centre. Thus the grab hangs a little to one side during the emptying process. If the one rope is now slackened, and the hauling rope held in position, the movable cross-bar descends, which movement is accelerated by a cast-iron weight. The downward movement of this cross-bar forces the jaws asunder as shown.

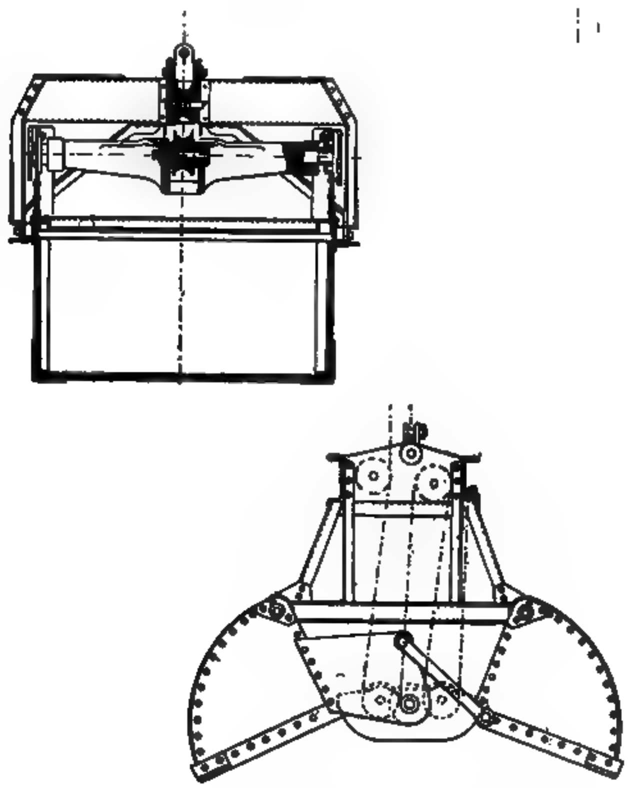


Fig. 272. Mohr & Federhaff's Grab.

The jaws of this grab open extra wide, the toggle levers forcing them further apart than they would move by their own weight. The same firm are also building a grab for handling larger pieces in which the movement is transmitted by means of wheels instead of chains and blocks. In this case the jaws are keyed to the spindles which support them, and are manipulated by the wheels, which are also keyed to the spindles. The chain supporting the load acts on two drums which are mounted on the same spindle, and placed close together. These drums revolve in opposite directions coinciding with the movement of the jaws. The chain is divided before entering the grab and is attached to the two drums A and B. Each drum is cast together with a pinion with 15 teeth, which are geared to wheels with 42 teeth, these again being attached to two inter-

mediate spindles on either side. These are fitted with two pinions of 10 teeth each which are geared into wheels on the jaws, and thus open and close them.

The latter are, as a matter of fact, only segments of wheels, each being about one-third of a whole wheel. This arrangement is made plain by Fig. 274, which shows the grab in elevation and also in cross section.

The gearing and the two countershafts are all enclosed in a sheet-iron casing

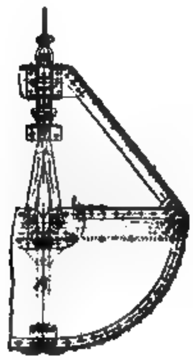


Fig. 273. Jaeger's Two-chain Grab.

which is visible in the illustration, and are therefore protected against the action of grit or any other foreign substance. The jaws are manipulated by means of a chain which is divided into four strands, each of which is attached to one of the four corners of the grab. This construction of grab is limited in its use on account of the division of

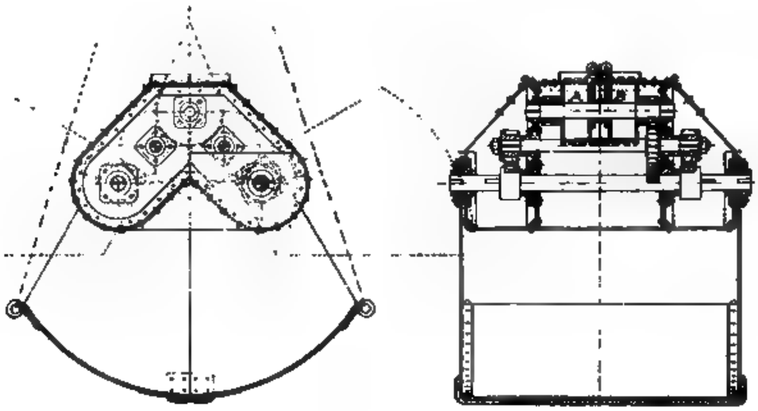


Fig. 274. Elevation and Cross Section of Jaeger's Two-chain Gear-driven Grab.

the chain, which will not admit of the grab being raised as close to the top of the jib as it can be in grabs of other design. It would, however, be suitable for work in connection with high-level cranes.

The useful effect of a grab depends to a great extent not only on the shape of the jaws but also on the nature of the material to be handled. The jaws of any grab will

more readily handle a light material of a uniform size than one which has a greater specific gravity and contains large pieces. There is no difficulty whatever with most kinds of grabs in the handling of grain, sand, small coal, &c., but when dealing with a material like iron ore a grab which would fill to its full capacity on the former materials would barely fill to half its bulk capacity on the latter material.

The angle of repose of the material is also an important factor in the filling process, as the greater the angle of repose the more difficult it is to gather the material into the grab.

It has also been maintained that the handling of coke or coal by grabs was detrimental to the material on account of the breakage which was deemed inevitable. But there is really no need for such breakage if a grab of suitable construction and design is used. As a rule the grab is dropped down on the material, which is bound to break under its weight, but there is no occasion to do this with grabs that are hinged from the haunches. These will fill just as readily when laid gently down on the material, as the action is in this case a gathering one, and the grab through this action buries itself in the heap. With grabs of this kind used in this way there need be no more breakage than in filling skips by hand.

Two-rope Grab of the Brown Hoisting Machinery Co.—This grab, which is illustrated in Fig. 275, has a capacity of 2 tons, and is used for unloading coal as well as for handling iron ore. The same firm make a smaller grab with a 1-ton capacity. The 2-ton grab when used on coal has a capacity of about 84 cubic feet, and when used on iron ore a capacity of about 35 cubic feet, which would mean approximately about 2 tons of either material.

When used on ore, the attachments marked GG which are bolted to the jaws are taken off, leaving the ends of the jaws open. The grab can thus only take a pile of ore as shown by the lines DEF; but when the grab is used on coal, and GG have been again attached to the jaws, the coal pile then taken by the grab is indicated by lines ABC.

This form of grab works satisfactorily with coal of all sizes, and it is specially claimed for it that it will handle very large pieces. It also works successfully with nearly all kinds of iron ore, with perhaps the one exception of some of the lumpiest Swedish ores. It has, however, been proved capable of handling satisfactorily all kinds of Spanish ores. The illustration gives over-all dimensions of the grab when open. This grab is manipulated in the following manner:—

The accompanying drawing, Fig. 276, shows a cross section through the grab when closed, with dotted lines indicating the path of its jaws from an open to a closed position.

To the housing of the grab is fastened a rail or track T, upon which are hung sliding blocks or pieces *bb*, pivotally connected with the forward portion of the jaws JJ. These jaws JJ are composed of two parallel sides *pp*, joined at their outer ends by cutting blades DD which are set at a sharp outward angle. The parallel sides *pp*, however, are cut away and recede upwardly from the lower or scraping edges toward their upper ends, so that when the jaws JJ are brought together and the grab thereby closed, a small portion of the grab's sides will remain open.

In the form shown in the drawings, the front and rear of the jaws are preferably unenclosed, and extend out beyond the housing when opened to their outward limit. The sides *pp* are stiffened by diagonal ties *ee*.

Centrally within the housing of the grab is the block C, carrying a series of sheaves M, mounted upon a common journal or shaft *j*.

The block is provided with trunnions which fit into vertical guide grooves, which are fixed on the inside of the casing. The lower ends of these grooves are closed so that the descent of the trunnions is limited.

At the upper end of the framing is a second block E, containing another series of sheaves M, which in the construction illustrated are one less in number than the sheaves of the lower block or head C. The sheaves in the blocks C and E are set at an oblique

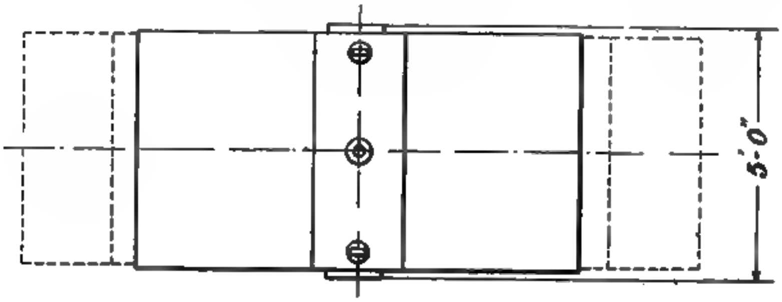


Fig. 275. Plan and Elevation of the Brown Hoisting Machinery Co.'s Two-rope Grab Bucket.

angle to the framing, so that the sheaves and off-running portion of the operating rope shall come on the centre line of the top of the grab. Rope guides or eyes *mn* are provided on opposite sides of the block E, with centres corresponding to the centre lines of the grab. Hinged to the block E is the hoisting block G, having rope guides or eyes *m'n'* at either side, being just opposite the guides or eyes *mn* on the block E.

O is the operating rope whereby the grab is closed or allowed to open. It passes downward through the eyes *m'* and *n'*, around the sheave in the upper block C, thence

upwardly round a corresponding sheave in the upper block E, down around the next adjacent sheave in the block C, and so on around any remaining sheaves, when the outgoing portion of the mechanism is carried up through the eyes n and n' to the hoisting mechanism.

R is the hoisting rope, which is reeved round the hoist block G, and connected with the winch in the usual manner.

The grab is operated by lowering the same above the material from which it is to derive its load, by paying out both the hoisting and the operating ropes. When in proximity to the material the hoisting rope is held taut and the operating rope O is slackened. The block C being thus freed, will, by reason of its weight, descend within the framing or the housing of the grab, being guided vertically by the trunnion grooves, and at the same time carrying with it and depressing the pivoted inner ends of the jaws JJ. It is evident that by this movement the said jaws being pivotally connected near their outer ends to the sliding blocks or pieces b and b, mounted on the guides T, said blocks will be forced outwardly along the track T, and carry with them the outer ends of the jaws JJ, and the grab will thereby be opened. The contour of the track T is such that, in connection with the vertical movement of the head C, the blades DD in their course in opening and closing will be constrained to describe any desired curve or course within the grab's limits—such, for instance, as that indicated by the dotted lines in Fig. 276. In practice, particularly where material is to be taken from flat surfaces or from against the sides of a bin or barge, the path of the blade-like part D should at the initial movement of closing descend with a sharp curvature that diminishes as the jaws approach each other, whereby the material is first penetrated by the jaws to some depth to ensure a purchase and load, and is then scraped together within the jaws of the grab.

Fig. 276. Cross Section through Brown Grab.

As indicated on the drawings, the downwardly projecting pieces S^1 serve to prevent the escape of material at the sides where the jaws are closed, and by leaving the rear of said jaws unenclosed any surplus load above the capacity of the grab will be forced out at the rear without in any way crowding within the grab, and thereby interfering with its proper working.

Both illustrations show the Brown grab with guide-bars T (which are connected to the movable fulcrums of the jaws) in a straight line. These guide-bars can, however, be made in any other shape, in which case the curve described by the cutting edges of the jaws will differ correspondingly.

Hone's Single-chain Grab.—The first successful single-chain grab was undoubtedly that on Hone's patent, manufactured by the Thames Iron-works and Shipbuilding Co. Ltd., Canning Town. Although of comparatively recent origin, this grab has undergone many changes in design.

The original patent, which was obtained by George Hone in 1882, consisted essentially of an oblong bucket fitted with a shifting bail, which was worked by a spring manipulated by an attendant on the crane by means of a string. The bucket descended in a vertical position, the line was then drawn taut, when the spring released the bail, and, changing its position, locked the apparatus. Then by a circular motion the load was filled and raised. It was not until a year later that the same inventor patented the grab which is illustrated in Fig. 277. It was similar in some respects to the present grab, as will be seen by the illustration and description further on.

Fig. 277. Earliest Form of Hone Grab.

Fig. 278. Hone Grab.

The patent for the grab as now manufactured was granted in 1894. This invention relates both to double and single chain grabs, but is chiefly used as a single-chain grab, though the principle of hinging from the haunches has been adopted, as already observed, by some makers of double-chain grabs.

The Hone grab, Fig. 278, apart from being a single-chain grab, was the first which pivoted the jaws from the haunches, that is from the extreme outside of the frame, thus getting a greater leverage, and therefore a more powerful closing of the jaws.

Taking grabs of the same size, those pivoted at the haunches will open their jaws much more freely as compared with grabs pivoted in the centre. The former, therefore, fill better, *i.e.*, take a larger load at each grip.

The working parts of the grab consist of *a rising and falling sheave block* A (called the sliding block), having two vertical loose sheaves mounted in it, and arranged to rise and fall within a guide of four vertical angle steels of the framework. *A single vertical loose sheave* B, mounted on a circular horizontal plate, this plate forming a cap to the

four vertical angle steel guides mentioned above, and having suitable holes in the plate for passing the crane chain through. *A crosshead* C, situated below the sliding block, and also free to rise and fall in the same four angle steel guides. This crosshead has a fixed vertical central pin with a semicircular notch across it. The top end of the pin is so arranged as to enter the vertical hole in the lower end of the sliding block, and the bottom extension of this pin is formed into lugs, to which the closing rods DD connecting the jaws are attached, so that when the crosshead is lifted in the guides the jaws are closed. *A locking pin and releasing lever* E. This horizontal locking pin fits into a horizontal hole through, and at the bottom of, the sliding block, in such a position that half its diameter passes through the notch in the vertical pin on the crosshead. The locking pin has also a notch in it, in such a position that when the notches come opposite each other the crosshead pin is free to disengage from the sliding block. The releasing lever E is "swung free" on one end of the locking pin, and having a balance weight F at its back short end, the long end at the other side of its centre is free to rise. A vertical stop and balance weight is fixed to the locking pin, and is of sufficient weight to keep the pin always locked. To this plate two stop pins are fixed, and the long end of the releasing lever E is always bearing against the top one in consequence of its balance weight. The second stop pin fitted on the same plate lower down is only provided for safety. *A ring* G, hung from the jib-head, of sufficient diameter to allow the vertical framework to enter it easily, but not large enough to allow the long end of the releasing lever to pass without being either depressed or raised. *A vertical oil-checking cylinder* H. This is fixed at its upper end to the top horizontal plate of framework, and its piston-rod passes through a gland at the bottom end of its cylinder, a suitable vertical clearing hole in the sliding block being provided, and is then attached to the crosshead C.

The grab is worked as follows:—

The ring G is hung from the jib-head at any required height which suits the point of discharge. Its position of course determines the releasing point.

To rig chain the free end of the crane chain is passed down through the central hole of the top plate, then under one of the sheaves in the sliding block below, up through second hole in top plate, under the second sheave in sliding block, and up again to the under side of top plate, to which it is attached by a bolt and lug, no special link being required.

It will be seen that the above operation, which is exactly similar to reeving a double and single chain block, can be effected by any unskilled labourer.

The grab is now attached to crane ready for work, and assuming it to be just landing into a barge of coal, then—

As soon as the grab has been lowered on to the coal (the crosshead C being at the bottom of the guides, and the sliding block A at the top of the guides) the sliding block will, by its own weight, and the overhaul of the chain, run down the guides until the crosshead pin enters the hole in the bottom of the sliding block. This also lifts the balance weights and the machine becomes locked. The grab is now ready to dig, and on starting the crane to "heave up," the sliding block and crossheads are pulled up between the guides at a leverage of 4 to 1, until the grab is completely closed. The load is then lifted to the required height, and the top portion of the grab must also be so far through the ring G that the long end of the releasing lever has been depressed by the ring, and having passed through it, has swung back again against the top pin. On lowering the grab, the releasing lever E comes in contact with the top edge of releasing ring G, thus lifting the stop plate and turning the locking pin until the two notches come opposite each other, when the crosshead, being released, falls from the sliding block, and the jaws and closing

rods drop with it. The piston-rod gently descends at the same time, thus preventing shock to the machine, or the scattering of the material.

On lowering clear of the ring, the releasing lever and locking pin reassume their

Fig. 279. Hone Grab with Four Jaws.

positions by means of their balance weights, and the grab is once more ready to be lowered into the barge.

Fig. 279 shows the same grab made with four jaws instead of two. This form is used chiefly for excavations under water and for extra stiff clay.

The following table gives dimensions, weights, and capacities of the Hone grab :—

Size.	Dimensions of Grab when Closed.	Approximate Weight of Grab.	Cubic Capacity in Feet.	Rate of Discharge in Tons of Coal per Hour with ordinary Steam Crane at about 40 feet lift.
	ft. in. ft. in.	Cwt.		
No. 1	3 6 by 3 6	13	15	20
„ 2	4 0 „ 3 6	14	18	24
„ 3	4 0 „ 4 0	17	23	29
„ 4	4 0 „ 4 6	21	30	37
„ 5	5 0 „ 4 0	22	35	43
„ 6	5 0 „ 4 6	24	39	45
„ 7	5 0 „ 5 0	29	44	50
„ 8	6 0 „ 6 0	48	78	72

Fig. 280 represents a form of the Hone grab for a single rope instead of the more usual chain; it is similar in action to the one previously described, and is built by J. Pohlig, of Cologne.

[illegible]

[illegible]

Fig. 280. Hone Grab for Single Rope as Built by Pohlig of Cologne.

Any ordinary crane can be used to manipulate a single-chain grab. All the attendant has to do is to raise and lower the grab whilst the filling and discharging is being automatically effected.

The Bleichert Grab.—Another single-chain grab is that illustrated in Fig. 281. This is also built on the "Hone" principle by Messrs. Adolf Bleichert & Co. of Leipzig. The action of this grab is as follows:—

In the closed position the two short outer chains KK are wound round on the spindle A, whilst the inner chain M hangs loosely in the interior or lays on the top of the material contained in the grab. The movable portion B is held in position by pawl C. The drum is held by the two pawls *cc* and the ratchet segments which form part of the drum. In order to discharge the load in the grab the two levers LL are made to touch an obstruc-

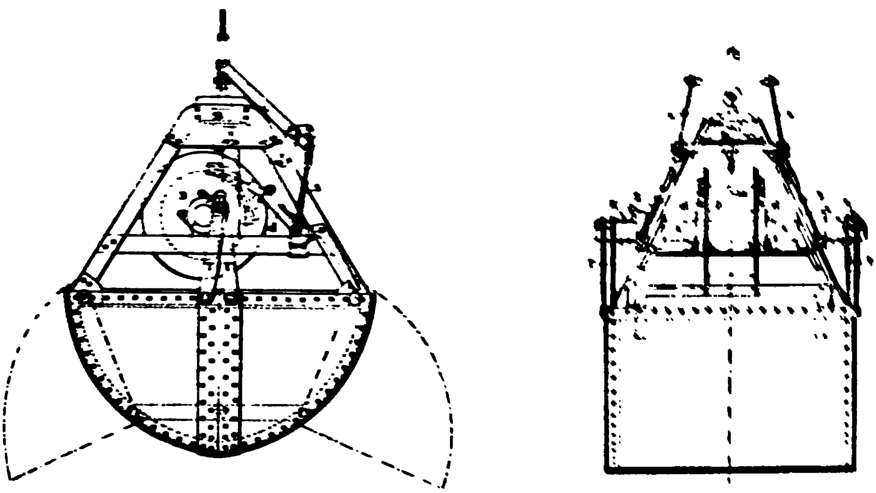


Fig. 281. Grab Built on the Hone Principle.

tion which is suspended from the head of the crane and is adjustable up or down. As this is in a fixed position, when the grab is being lifted, the levers LL are forcing down, by

means of two short chains, the pawls *dd*. The drum D which is fixed to the spindle A is compelled to revolve through the weight of the grab and its load so that the two small chains KK unwind from the spindle A, whilst the hitherto slack chain M winds itself on the drum D during the process of opening. As soon as the apparatus has thus been discharged the main chain begins to lower, when the levers LL, being released from the obstruction, are pulled back into their original position by the springs SS, while the pawls *dd* hold the drum D in its position, and thus keep the jaws open as the grab plunges into the material to be elevated. If the rope or chain be now further lowered, the part B sinks by its own weight into the opening in the top of the framework, and in so doing the pawl C is pushed to one side and held in that position by another small catch. The hoist chain is now pulled up by the crane, B is now no longer held in position, and as it is pulled out of the framework, pulls with it the chain M so as to unwind it from the drum D. The revolutions of the drum, and with it of the spindle A, wind up the two small chains KK, and pull up the levers TT, thus closing the jaws. As soon as the grab is thus closed, the chain is lowered once more for a foot or so. B re-enters its former position, and is now again held in place by the pawl C, which has in the meantime been released. As B re-enters the frame, the chain M is released and lays loosely on top of the load as the drum is now fixed. The grab is now ready to be lifted and swung into position for delivery.

Pneumatic Grabs.—A grab operated by compressed air is built by the W. H. Beard Dredging Co., of New York. The jaws are opened and closed by means of air pressure. The contention of the inventor is this, that the grab when embedded in the material to be raised should be closed without pulling a chain or rope, as this might have a tendency to loosen the hold of the jaws upon the material, with the effect of diminishing the load to be raised.

The pneumatic grab is shown in Fig. 282.

Fig. 282. Pneumatic Grab of the Beard Dredging Co.

From the chain of the grab is suspended a frame A, which carries the air cylinder B and the crosshead guide which supports levers CC. Although this grab has only one chain, its manipulation is somewhat complicated.

There are two air pipes to be raised and lowered with the grab, one to connect the upper and one to connect the lower end of the cylinder with the compressed air vessel. This is effected in the following manner:—A drum is fixed to the jib-head of the crane, and to its hollow spindle the two air pipes are attached by means of stuffing boxes on either end. The two flexible air pipes leading to the grab are rolled upon the drum, one end of each being connected with the main pipe through the stuffing boxes. As the grab descends, the pipes unroll from the drum and cause the latter to revolve, thus winding a rope (on the end of which is a balance weight) upon the drum, so that as soon as the grab ascends again the weight on the rope turns the drum in an opposite direction and winds the two pipes up again, so that they are always taut no matter in what position the grab may be. To manipulate the grab a three-way valve is used, two of the exits communicating with the upper and lower end of the cylinder, and the other with the compressed air vessel.

Hydraulic Grabs.—These grabs are similar to the last mentioned, but are operated by hydraulic power.

Fig. 283 illustrates such a grab. The arrangement of the jaws and their guides is similar to the Priestman principle.

The casting upon which the jaws are hinged is connected to the cylinder by powerful vertical rods. The lower large piston closes the jaws, whilst the upper is for the purpose of withdrawing the former, and thus opening the jaws. Both pistons are connected together by rods. The stuffing boxes are easily accessible. This apparatus is said to be satisfactorily at work in the United States and elsewhere.

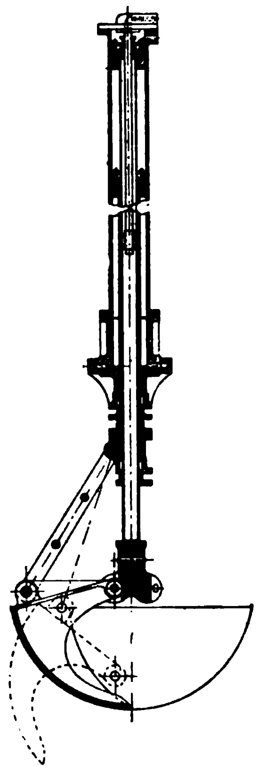


Fig. 283. Hydraulic Grab.

In order to show at what great speed coal may be unloaded with the Hone grab, the following example may serve as a good illustration.

At the Beckton Station of the Gas Light and Coke Co., the collier "Eleanor," having a cargo of 2,750 tons of coal, was discharged in 6½ hours by a No. 7 Hone grab, manipulated by hydraulic cranes.

The following extract from a paper read by Mr Charles Claude Carpenter, M. Inst. C.E., and Deputy Chief Engineer of the South Metropolitan Gas-works, London, shows how considerable a saving can be effected by the use of the grab as compared with the non-automatic skip:—

"The consumption of coal for gas-making purposes in the United Kingdom is about 13,000,000 tons per annum, of which quantity the three metropolitan companies use upwards of 3,250,000 tons.

"By the action of the sliding scale, which automatically regulates their dividends in accordance with the price charged for gas, the companies have a direct interest in keeping this as low as possible.

"A saving of 1d. per ton upon the coal carbonised in London is equal, in round numbers, to £13,500 per annum. As the cost, with the hand labour, of coal unloading, carbonising, and handling the resultant coke is approximately 4s. per ton of coal, the possibilities and economies of substituting machinery will be apparent.

"In the case of the majority of the London works, coal is brought alongside in ships or barges, unloaded by steam or hydraulic cranes, and deposited in the retort houses or coal stores as required. The cost for hand labour is as follows:—

	Per Ton.
Fillers	3d.
Tippers	½d.
Crane drivers	½d.
Truckmen	¾d.
Total	4¾d.

"By means of self-acting grabs it is possible to considerably reduce the first item, and to eliminate the second altogether.

"The figures will then be as follows:—

	Per Ton.
Filling and trimming for grab - - - -	$\frac{3}{4}$d.
Crane drivers - - - - - - -	$\frac{1}{2}$d.
Truckmen - - - - - - -	$\frac{3}{4}$d.
Total - - -	2d."

This shows a saving of 2$\frac{3}{4}$d. per ton, which means £37,125 per annum on the handling of coal for gas-works alone, and it must be borne in mind that the unloading out of barges by grabs is only a part of the process of automatic handling. It ought here to be said that of the 3,250,000 tons of coal used in London gas-works, all does not arrive in barges, but when dealing with coal carried by rail, hand labour can again to a great extent be dispensed with by means of tips and special trucks which are dealt with in another chapter.

Dredgers and steam navvies might also be termed machines for the mechanical handling of material, although they are essentially for excavating and digging purposes. The mechanical handling being as it were an auxiliary, apart from their actual purpose, descriptions of these machines have been omitted in this book.

CHAPTER XVIII.

DISCHARGING VESSELS AND BARGES BY MEANS OF ELEVATORS.

Barge elevators are elevators as described under this heading, but fixed in such a way that they can be lowered into barges or other vessels for the purpose of unloading. They are more particularly suitable for material of a small and uniform size. Grain and seeds, such as cotton or linseed, as well as small nuts, and in fact all small material, can readily be cleared out of a ship's hold by lowering the elevator into the bulk of the material to be conveyed, when it will feed itself. All that is required on the part of the attendant is to keep lowering the elevator as the vessel is cleared. The last remaining layer of course will have to be trimmed up in a heap round the bottom of the elevator.

Cargoes of coal or of ore of uneven size in which are contained larger fragments can only be handled by barge elevators in cases where the material can be thrown into the elevator bottom by hand, except when the elevator buckets are large enough to hold a number of the largest fragments at a time, in which case the elevator might be partially automatic and require only a little manual assistance.

Fig. 284 is an example of a barge elevator for coal. The full lines show it in working position, whilst the dotted lines show it out of work and placed out of the way of the canal traffic. The elevator is lowered into one end of the barge to be emptied, and the coal is trimmed into the elevator bottom by means of shovels, and when one end of the barge is empty she is moored a little further away until the opposite end has reached the elevator. The elevator itself delivers its load by means of a hinged spout into a swinging conveyor at the top terminal which distributes the coal over the coal store or other destination.

Elevators have already been described in the early part of this book, so that all that has now to be considered is the mode of fixing them when used as barge elevators. It is of great importance to support an elevator in its suspended position in such a way as not to burden the top spindle with the weight of the elevator casing.

In the illustration, Fig. 284, the elevator is suspended at a point 6 feet below the top spindle and at one end of a lever 16 feet long, which has a balance weight at the other end to equalise the weight of the elevator.

This mode of fixing has the advantage that the elevator can be moved round its support and swung into any position across the width of the barge. The winch on the supporting column controls the raising and lowering of the elevator.

A barge elevator for grain, small coal, &c., would be arranged just as that shown in the illustration, with the exception that the elevator bottom has no inlet spout, but is of open construction, so as to admit the grain to the elevator well to be received by the buckets.

Fig. 285 is a similar design of a barge elevator feeding a band conveyor. The elevator itself is driven from the conveyor, the latter receiving its motive power at the

opposite end. It is suspended by means of two steel ropes; one end of each can be wound upon one of two drums, on either side of the elevator casing. The hand-wheel A controls the gear for lowering and raising the elevator. This is effected by means of power obtained from the band terminal. Each drum is fitted with a worm and worm wheel. The elevator must always be in a perpendicular position, and is there

Fig. 284. Barge Elevator for Unloading.

maintained by four small guide rollers which prevent any side movement, but allow of an up-and-down motion.

As the rise of the elevator is only a few feet, owing to the barges being shallow and there being no tidal variation in the river, the gearing of the band to the elevator is in no way detrimental to the arrangement, for even if the elevator and band are at their highest points the efficiency of the latter is not in any way impaired.

The whole of this installation is equally suitable for unloading grain, &c., with the slight modification at the elevator well already mentioned.

The appliances dealt with in this chapter are mostly used for the purpose of unloading small vessels, and are perhaps more usual than either of the other methods mentioned; namely, discharging by means of skips or grabs, and discharging by means of self-emptying barges. The latter are, however, sometimes used in conjunction with barge elevators.

The best method of dealing with large quantities of seeds or grain in granaries,

Fig. 285. Further Type of Barge Elevator.

flour and oil mills, is dealt with elsewhere, so that under this heading barge elevators only need be considered. There are a great many of these appliances now at work, and the following are a few typical examples.

Portable Ship Elevators.—These are very similar to the elevators attached to factory buildings and gantries for the purpose of clearing grain, coal, and similar materials from ships' holds. As has previously been explained, they can only be used

for coal which is of a fairly uniform size. The installation illustrated in Fig. 286 consists of two elevators mounted on a movable carriage with steam engine and boiler.

One of the elevators is a fixture, whilst the other is suspended from the jib end of a derrick, and can thus be lowered into the hold. There is a conveyor between the delivery end and the feed end of the two elevators, so that no matter in what position the movable elevator stands the material is conveyed from one to the other. The fixed elevator delivers into the hopper, so that the grain, &c., can be filled in sacks before it is loaded into the railway trucks. The illustration here given is a front elevation and side view of the design of Messrs Unruh & Liebig, Leipzig.

Fig. 286. Unloading Device by means of Barge Elevator.

A similar installation is shown in Fig. 287.

The latter is rather more compact, but is only suitable for quay sides where no attention need be paid to the varying tides. This is driven by an electro-motor, the cable which supplies the current being concealed in a leather tube so as to allow the truck the necessary latitude in its movements on the quay. The hopper which receives the grain is fitted with an automatic weighing machine.

Barge Elevators at Copenhagen.—A similar installation has been erected by Messrs Unruh & Liebig, Leipzig, in connection with a large flour mill at Copenhagen. This elevator has been at work since 1882, and is used either for conveying the grain

to the silo warehouses of the mill direct, or for loading into railway trucks upon the quay. It is suitable for discharging grain from sea-going vessels. The capacity is about 60 to 80 tons per hour. The conditions are such as to render it necessary to resort to an altogether different type of barge elevator to that usually employed, the variation, not only in the tide, but also in the depth of grain in the ship's hold, making it necessary to have an elevator which could be adapted to widely varying levels.

The installation, which is illustrated in Fig. 288, consists of a rectangular carriage mounted on suitable rails, to the end of which is attached a fixed derrick. The elevator itself is attached to the derrick, and can thence be lowered to any desired point.

The elevator can be lengthened or shortened by an ingenious arrangement, which may be seen from the illustration. The position in which it is shown is with the band and buckets extended to their utmost limit. If it be desired to shorten it, the head

Fig. 287. Unloading Device with Barge Elevator.

gear of the elevator itself is pulled back so as to take up the surplus band and buckets, this backward movement of course altering the delivery point. By means of this device a number of suitable outlets AA are provided. These lead to the band conveyor, which in its turn takes the grain to the mill. The buckets are of such a shape that they do not spill the grain even when the top portion of the elevator is fairly level.

Barge Elevator for Grain.—A good example of a movable barge elevator is that illustrated in Fig. 289. It is at work at the Eagle Oil Mills of Messrs J. Rank Ltd., Hull, and was built by Messrs Spencer & Co. Ltd., Melksham. It is driven by electricity, it is self-propelling (a portion of the track being given in the illustration), and is capable of raising 60 tons of seed per hour. The whole of the machinery for operating the elevator is erected in a corrugated iron cabin, which is movable with the elevator on the track. Travelling gear is provided in order to minimise the necessity of

trimming as much as possible, as at low tide these barges are lying on the mud, so that it would not be possible to move them higher or lower for unloading purposes. The elevator delivers in any position of its travel through a telescopic shoot on to a band conveyor carried on a gantry, which afterwards discharges through a suitable spout into the mill.

The electric current is conducted along the face of the warehouse wall, which is fitted with a number of wall plugs, from any of which a connection can be made by flexible cable to the motor.

Fredenhagen's Barge Elevator.—Fig. 290 illustrates a ship or barge elevator fitting into a movable framework which can be deposited above the hatch, leaving an

Fig. 288. Barge Elevator at Copenhagen.

opening sufficiently large for the elevator to descend into the hold, as may be seen from the illustration. The elevator itself is suspended from the rigging by a chain, and has a driving gear which runs over two guide pulleys and thence to the top and bottom terminals; it will therefore be in gear in whatever position it may be relative to the main drive and its framework.

It is built by Fredenhagen, of Offenbach-on-the-Main, Germany, and has a capacity of 120 tons per hour. The delivery is effected by a telescopic spout, which can be led into a barge or ashore, wherever the grain is to be delivered.

Travelling Grain Elevator at Avonmouth Docks.—This installation was erected by Messrs Spencer & Co. Ltd., of Melksham, for the Bristol Docks Committee at the Avonmouth Docks.

The elevator was designed for a capacity of 75 tons per hour, but was proved on test capable of taking from a vessel's hold rather more than 100 tons of grain per hour.

Fig. 289. Travelling Barge Elevator at Eagle Oil Mills, Hull.

It is built on the balanced lattice girder principle, and has double elevator legs so arranged as to operate on both sides of the steamer's shaft tunnel or cargo-parting

boards, thus reducing the cost of trimming considerably. The whole structure is mounted on eight wheels, having a wheel base of 20 feet, and arranged to run on rails

Fig. 290. Type of Barge Elevator.

laid down at 12 feet gauge. Hand gear is fitted to these travelling wheels in such a manner that the whole apparatus may be shifted by means of manual labour.

The elevator itself stands 100 feet high when housed, and is capable of unloading

vessels up to 55 feet beam. It is so constructed as to lift the grain from any level within a range of 25 feet below the coping of the quay, and to rise clear over the vessel's hatches when such are 22 feet above the coping edge, thus having a total range of travel of no less than 47 feet up and down.

Fig. 291. Ship Elevator at Avonmouth Docks in Housed Position.

The elevators are fitted with buckets 13 inches wide which are pitched 12 inches apart.

Fig. 291 shows the elevator in a housed position when not in use.

Fig. 292 shows it at work taking grain from a vessel's hold and delivering to the granary alongside. The total weight of the whole apparatus is between 90 and 100 tons,

and there are no less than 18 tons of balancing material used in the back end of the lattice girder.

This installation is driven by electro-motors, one motor being provided to drive the elevator itself and the receiving band conveyor, which is connected therewith, also the controlling hoist. Another motor is provided for driving a set of power trimming gear used for trimming the grain to the elevator.

A machinery house has been provided on the structure which contains these motors, the trimming gear, and the controlling hoist. It contains also all necessary levers and hand gear for manipulating the various parts of the apparatus. A full view of the deck of the vessel and alongside can be obtained from the windows of the machinery house, to which access is obtained by ladders and platforms, as shown in the illustrations.

Fig. 292. Elevator at Avonmouth Docks when at Work.

A band conveyor attached to the upper side of the lattice girder is provided for receiving the grain at the elevator head, and is fitted with suitable feed hoppers for receiving grain from a set of telescopic shoots in connection with the elevator head; it is also furnished with a telescopic shoot for discharging the grain at the back of the structure to the transit shed alongside. The trimming gear for feeding the grain to the elevator in the vessel's hold consists of four large wooden grain trimming shovels or ploughs, strongly built and framed. A suitable winch, driven by an electro-motor and intermediate gearing, furnishes the power for propelling these shovels. There is also a complete equipment of ropes with fixed and portable snatch blocks for guiding same from the winches to the shovels.

An automatic gear and electric signalling apparatus are provided for the purpose of

throwing out of gear automatically, at a predetermined time, any particular winch and shovel. The electric signalling apparatus is so arranged that instructions may be given

Fig. 203. Barge Elevators at Messrs J. Dudin & Sons' Wharf.

from the hold of the vessel to the attendant in charge to stop or start any particular shovel as the trimmer man may require.

The whole plant * proved so satisfactory that the Dock Committee ordered a similar

* See *Milling*, 6th June 1903.

installation for their grain docks in Bristol. The new elevator at Bristol Dock is rather larger, and is provided with weighing appliances on the structure itself, so arranged that the grain may be delivered either in sacks or in bulk.

Spencer's Barge Elevator.—This appliance is largely in use. A typical installation is shown in Fig. 293. This is at the wharf of Messrs J. Dudin & Sons, London, where three such elevators are at work. The elevators are made with steel casings, and have each a capacity of 30 tons per hour. Each elevator is supported on the jib by means of spring hinges, which are sufficiently flexible to prevent any damage to the elevators from any side movement which might be caused by the traffic in the river during their use.

Rigg's Floating Elevator.—Fig. 294 illustrates this apparatus, which consists of an endless chain for conveying coal, minerals, or grain from barges into carrying steamers.

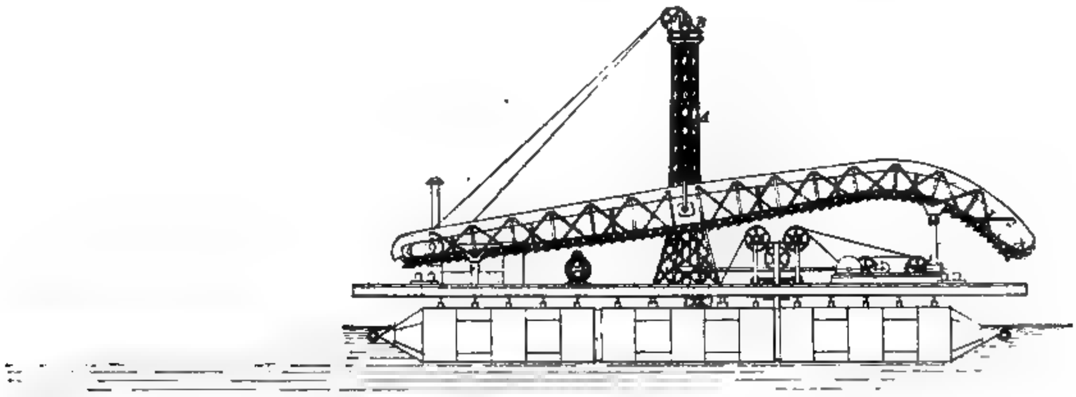


Fig. 294. Rigg's Floating Elevator.

It will be seen from the illustration that the two pontoons carry a deck of about 74 by 24 feet beam. Supported about the centre of this deck is a lattice tower A, the top of which is fitted with a revolving cast-iron head B, from which are suspended a pair of steel lattice girders CC′, each carrying an elevator.

These girders are raised from the fore and aft position to the direction athwart, the power for this purpose being taken from a pair of 7 by 14 inch winding engines and a semi-portable boiler, which also operates the elevator by means of an endless wire rope.

The suspended girders are also hauled into position to suit the lighter or steamer to be loaded by means of hand winches, and either of the elevators can be lowered so as to suit both the hold and the load in the lighter. Some idea may be formed of the facility with which they are raised and placed athwart when it is stated that the former operation has been performed in seventy-five and the latter in ninety seconds.

The same appliance may be equally as well used for loading grain as coal, but in the former case the buckets on the elevator are closer together. It has thus raised grain at the rate of 150 tons per hour. The buckets will fill automatically when dipped into a grain-loaded barge, but this is not the case when cargoes of ore or coal (containing large fragments) are being handled. The capacity is then limited in a great measure by the

filling capacity of the staff of trimmers or loaders, who are placed in close proximity to the foot of the elevator. Under such conditions eight men can load about 60 tons per hour.

Mr Rigg gives the following as a fair estimate of the economy resulting from its use in the purpose for which it was mainly designed, namely, the coaling of steamers. In the following calculations it is assumed that the elevator would be in actual operation for only three days of the week. A crew of four is sufficient to discharge the duties on board the pontoon and in making the connection to bunkers. The rate for filling the passing buckets of the elevators is taken at the same rate as is paid for loading the baskets passed from man to man in coaling by hand. The labour of trimming in the bunkers being the same in each case, these charges also are alike.

COST OF BUNKERING WITH RIGG'S ELEVATOR.

		£	s.	d.
Engineer per week		£2	0	0
Stoker per week		1	7	0
Unskilled labour (two men)		2	10	0
		£5	17	0
Depreciation—				
Elevator, including engines, boilers, gearing, and pontoon	£2,400			
Coal distributing troughs	100			
	£2,500			
10 per cent. per annum for one week on £2,500		£4	16	2
Coal and stores per week (three working days)		3	5	0
		£13	18	2
Filling—				
8 men each 7 tons per hour, 56 tons per hour, or 560 tons in 10 hours (1 day), 1,680 tons in 3 days, at 1¼d. per ton		£8	15	0
Trimming 1,680 tons in bunkers at 2½d.		17	10	0
Royalty on 1,680 tons at ½d.		3	10	0
		£43	13	2
Present quay charges, 1,680 tons at 1s. 6d.		126	0	0
		£82	6	10

This works out at the following figures:—

	Per Ton. s.	d.
Cost for trimming by hand	1	6
Filling by Rigg's elevator	0	6¼
Difference	0	11¾

This means a saving of nearly £50 in loading a steamer with 1,000 tons of coal.

The full capacity of the plant is equal to double that of the eight men represented as loading, and this number may therefore be increased under pressure.

Floating Derrick Elevator.—The derrick elevator of the London Grain Elevator Co. at the London Docks is the joint invention of Mr A. S. Williams of the Atlantic

Fig. 295. Derrick Elevator ready to be lowered over Ship's Side.

Transport Steamship Co., Capt. W. K. Brown (manager) and Mr A. H. Mitchell (engineer) of the same company.

This derrick unloading elevator is shown in Figs. 295 and 296.

The former illustration shows the elevator ready to be lowered over the ship's side for unloading purposes, whilst the latter shows the elevator at work discharging grain.

Fig. 298. Derrick Elevator of the London Grain Elevator Co.

It might appear from the illustration to be a somewhat cumbersome appliance, but as a matter of fact it is exceedingly simple to manage.

It has been designed for unloading grain from the largest types of American liners

engaged in the grain trade (such vessels as the "Minnehaha" and sister ships of the Atlantic Transport Co.) into lighters for conveyance into other coasting vessels or into warehouses.

The first elevator of this type was built by Spencer & Co. Ltd., of Melksham. The whole plant consisted essentially of four parts. Firstly, the pontoon; secondly, the travelling car, containing the engines and the various driving gears; thirdly, the support, consisting of lattice girders and shear legs; and fourthly, the elevator itself, which is lowered into the ship's hold. The pontoon is built of steel, and is 75 feet long by 24 feet wide, and has a draught of 8 feet. It is square at the bow so that it can be brought close to the side of the vessel which is to be discharged. The deck of the pontoon is specially strong, and is fitted with a track, the rails of which run from bow to stern, and are 7 feet apart. The travelling car moves on these. There are two vertical boilers in the stern, one being sufficient to drive the plant, the other only being used in case of emergency. Ample bunker space is allowed amidship.

The pontoon is self-propelling by means of a small marine engine and a pair of screw propellers. The space in the hold not required for bunker purposes is filled with ballast to ensure the stability of the vessel. The trolley, which is 17 feet long by 9 feet wide, rests on the rails on six wheels. The range of its motion from end to end is 36 feet. It is conveyed backward or forward by a pair of wire ropes which are fastened at one end to the pontoon and at the other end to the drums of the winches. The engine, which is in the centre of the trolley, is a 30 HP. of double-cylinder type, and is connected with the boiler by flexible pipes, the connection being made in the centre of the revolving drum in such a way that the piping rolls itself on or off the drum as the trolley moves backward or forward.

The large lattice girders of the derrick shown in the illustration are carried on trunnions on the forepart of the trolley, while the main shaft which drives the elevator and conveyors passes through these hollow trunnions. In front of these is the gearing for raising or lowering the main jib, and the gearing for moving the elevator to a vertical position. The trolley is cased in, and forms the attendant's cabin, in which all the levers for manipulating the different parts are placed. The housing has been removed for the purpose of taking the photographs from which these illustrations were prepared. The structure at its supports is formed of two pitch pine shear legs in the bow, one on either side, and a lattice steel back leg which is about 50 feet long. These shear and back legs are connected together at the top by a steel pin and collars, the back leg being hinged to the trolley and the front legs to the deck of the pontoon. All these parts can readily be raised to any angle, allowing perfect freedom for the trolley to move backward and forward on deck. The elevator is supported by a jib which is hinged to the back leg, as shown in the illustration. On this jib is fitted a band conveyor 2 feet 6 inches wide. This conveyor is necessary, as the elevator itself dips deep down into the ship's hold, and the grain may have to be conveyed up or down to reach its destination; but with the aid of this band conveyor the grain can readily be discharged, no matter in what position the elevator may be.

Just below the jib on the other side of the back leg extends a cantilever projecting over the stern of the pontoon, at the end of which are two long shoots for the delivery of the grain. This cantilever is also fitted with a band conveyor which receives its feed from the band conveyor on the jib. The two delivery spouts are fitted with a revolving valve, so that the grain can be discharged on either side or on both sides. The elevator itself has a steel casing and two pairs of internal chain wheels with two chains. The buckets are 20 inches wide, and of the continuous type, similar to those illustrated in Fig. 8, page 15.

The elevator has a vertical range of 18 feet, and when at its maximum height its head is 90 feet above the water level. It is 53 feet long, and a clear height of 40 feet is allowed between the bottom of the elevator and the water level when the elevator is in its highest position, so that the latter can be carried over the side of any ship. It may be mentioned that this elevator can discharge grain from a ship's hold 45 feet deep, and having a 40-foot beam. The driving power required to manipulate it when in full work is 20 B.HP. The expeditious way in which the elevator can be set to work may be gauged from the test in which it was lifted over the bulwarks of a ship 30 feet 6 inches above the water level, lowered into the hold to a depth of 43 feet, and started to work delivering grain in seven minutes.

This elevator can be housed very neatly when out of use, in which case it lies flat upon the deck, and the delivery shoots are drawn in, so as not to project over the sides of the pontoon. The position of the shear legs when the elevator is housed is approximately at an angle of 35 degrees to the deck. To bring the elevator into action the main jib is hauled in, while at the same time the end of the jib moving in the slot in the side of the elevator trunk travels to the lowest point of the slot, with the result that the elevator is raised to a considerable height and rests in a vertical position in front of the shear legs. The pontoon is then brought with its bow against the side of the grain vessel. This is facilitated by the square nose of the pontoon. The elevator being sufficiently high above the bulwarks, will be over the hold when the pontoon touches the ship's side. It is then lowered into the hold of the vessel as shown in the illustration.

The capacity is 150 tons per hour, and this can be kept up provided the trimmers can keep pace with it.

This elevator is in use at the Victoria and Albert and also at Tilbury Docks.

CHAPTER XIX.

UNLOADING BY MEANS OF SPECIALLY CONSTRUCTED SELF-EMPTYING BOATS AND BARGES.

THE methods of unloading barges described in the two previous chapters satisfactorily answer their respective purposes, but where quick delivery is essential, self-trimming barges and boats are employed. It might correctly be said that appliances of this kind are as yet in their infancy. In fact, a number of costly self-trimmers were given up as useless before the appliances at present in use were constructed.

Self-trimming barges are used for the purpose of transferring their contents, which may be grain, coal, &c., to other vessels, or to the receiving elevators or conveyors of granaries and coal stores.

Paul's Self-trimming Barge.*—One of the oldest self-trimmers, which is, however, not entirely automatic, is the design of the French engineer, M. J. Paul, and will, it is claimed, successfully handle grain, coal, sand, &c.

Fig. 297 shows such a barge, which has a double bottom forming a hollow space BB

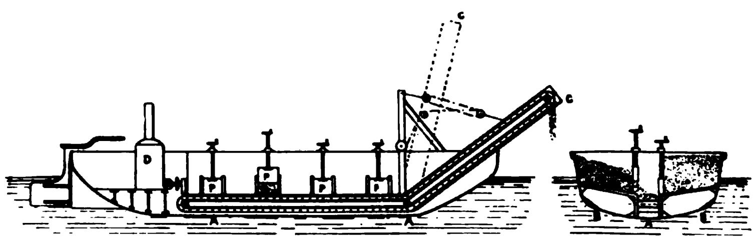


Fig. 297. Self-trimming Barge of Monsieur Paul.

on either side of the channel A, in which a travelling trough conveyor is fitted in such a way that its delivery end is movable like a derrick. Section AC of the conveyor can therefore be raised or lowered to suit the requirements of the delivery. The angle must not, however, exceed 45 degrees. When not at work the movable part can be raised out of the way as shown by dotted lines. The contents of the barge are fed to the conveyor through the openings P which are adjustable by means of hand wheels and screws. D represents the engine and boiler. Barges of this description are credited with a discharging capacity of 200 to 250 tons per hour.

Self-trimming Barge in New York Harbour.†—A very complete self-trimming barge is in use in New York Harbour for the purpose of conveying coal.

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* This barge has been minutely described by Professor Buhle.

† This barge was fully described in the *Journal of the American Society of Naval Engineers*, February 1901.

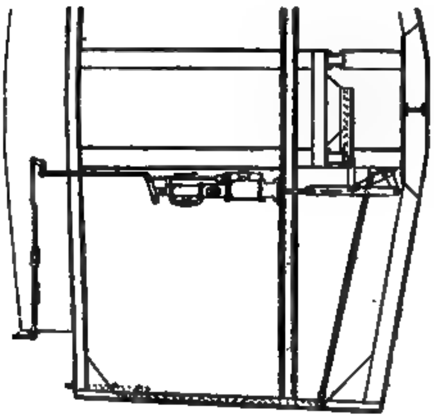


Fig. 299. Pneumatic Machinery for Controlling Slides.

Fig. 301. Cross Section through Self-trimming Barge.

Fig. 298. Longitudinal Section through Self-trimming Barge.

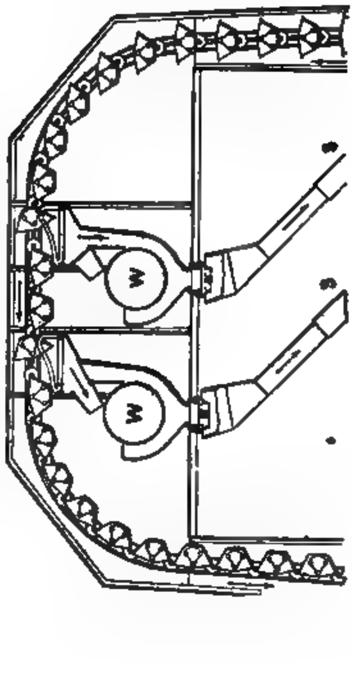


Fig. 300. Discharging Point in Self-trimming Barge.

It has this advantage, that it is really self-trimming, and empties itself completely. It creates but little dust, and the coal is weighed automatically before delivery into the bunkers of the vessel.

Fig. 298 represents a longitudinal section through the barge. AAA are the compartments in which the coal is deposited. Each compartment is fitted at the bottom with three slides, which are opened and closed by hydraulic machinery illustrated in Fig. 299. Below the row of slides is a tunnel in which a gravity bucket conveyor is fixed, which is driven by a small engine and boiler at the stern of the vessel.

The contents of the different receptacles are in rotation deposited on the conveyor and moved in the direction of the arrow. On reaching the stern, the conveyor ascends, and the buckets are emptied in their highest position into the automatic weighing machines WW, from which the coal slides down the shoots SS into the bunkers of the steamer to be loaded (see Fig. 300). The shoots SS can be raised or lowered by means

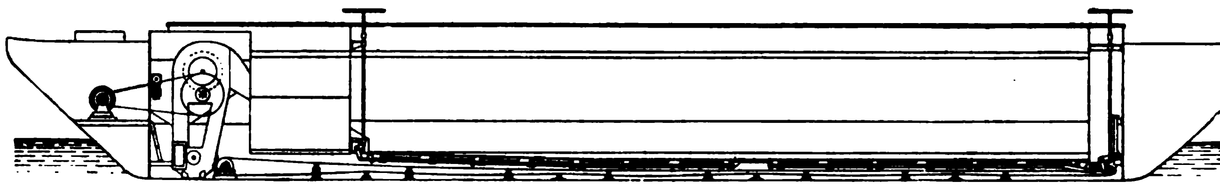


Fig. 302. Longitudinal Section through Philip's Self-trimmer.

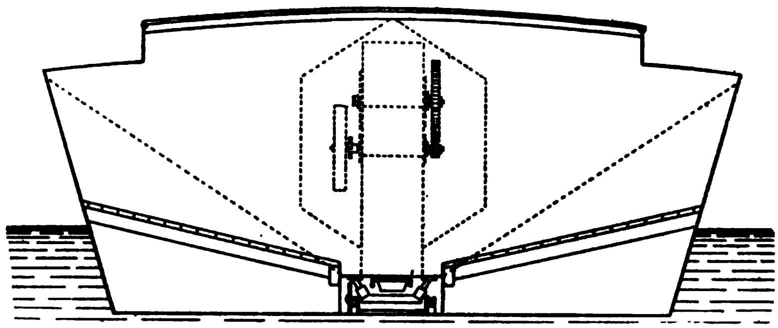


Fig. 303. Cross Section through Philip's Self-trimmer.

of winches. Fig. 301 represents a cross section through this self-trimmer showing the hydraulic machinery for raising the bottom of the compartments A after they have partially emptied themselves, for the purpose of automatically completing the discharge. Coal can be unloaded from this barge at the rate of 100 tons per hour. Two such self-trimmers are used, one at either side of the vessel.

Philip's Self-trimming Lighter. — Philip's lighter is illustrated in Fig. 302, which gives a longitudinal section of the same, whilst a cross section is shown in Fig. 303.

Fig. 304 gives the two ends of the lighter on a larger scale. These lighters were designed and equipped by Messrs Spencer & Co. Ltd., of Melksham, for the London Grain Elevator Co.

There is a fleet of twenty-six of these lighters, which carry a load of 200 tons of grain each from Tilbury to the Port of London, the large grain steamers not being able

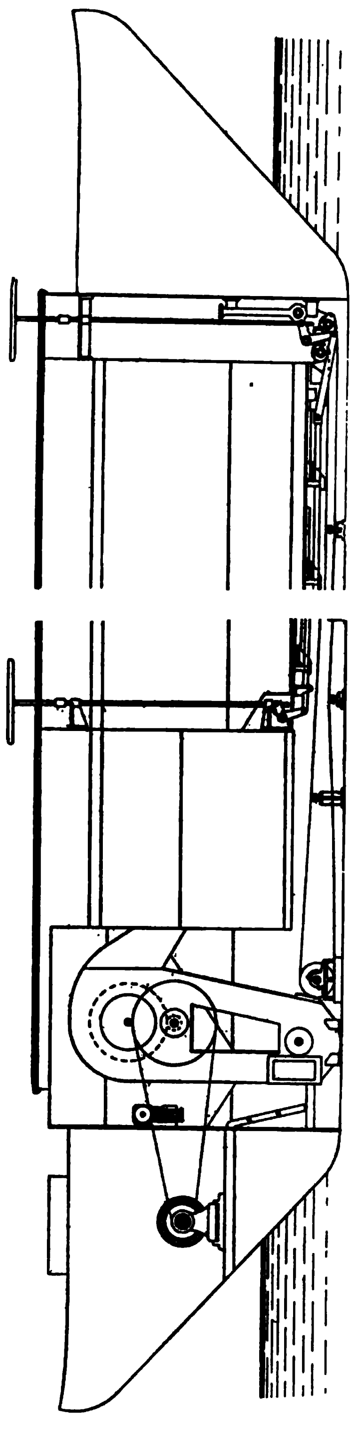


Fig. 304. Giving View of Stern of Self-trimmer, also Bow of same.

Fig. 305. Longitudinal Section through the Self-trimming Barge of the Pittsburg Coal Co.

to come up higher than Tilbury. The lighters discharge grain at the rate of 120 tons per hour into a barge elevator, which receives it and discharges it into the granaries of the London Grain Elevator Co.

Between the double keelson of the lighter runs a band conveyor of the ordinary type, the band being 28 inches wide. This band delivers into the elevator situated at the stern of the lighter. Both elevator and conveyor are driven by an electro-motor of 6½ B.H.P. The bottom of the barge is hopper-shaped, as may be seen from the cross section. Although the angle is not sufficient for the whole of the grain to discharge automatically, but little trimming is required to remove any small portions of grain which may remain at the sides after the bulk has been cleared. The openings from the barge to the band are adjustable, and are controlled by means of hand wheels, one at each end of the barge controlling one half of the outlets.

Self-trimming Barge of the Pittsburg Coal Co., Cleveland, Ohio, U.S.A.—This barge was built by the C. O. Bartlett & Snow Co., and is illustrated in Fig. 305.

The illustration shows a longitudinal section through the barge, giving a general view of this self-trimmer, and showing the construction, which is as follows:—

The barge is about 165 feet long by 25 feet beam, and is large enough to carry 750 tons of coal in addition to her machinery. The main body of the barge is divided into a series of hoppers, each 10 feet wide, which extend nearly the entire length of the barge. The hoppers A are arranged in two rows, one on each side, leaving the tunnel in the centre, which extends from end to end through the barge. Each of the sixteen hoppers communicates with the tunnel by an outlet B, which is 3 feet square. From this the coal can be deposited on conveyor E, running through the tunnel. The conveyor consists of two strands of a very heavy chain, to which are connected flytes, which form, with the chain, a form of push-plate conveyor. The coal is allowed to pass from one of the hoppers A to the conveyor, and is then removed to the conveyor terminus, which is raised slightly above the level of the rest of the conveyor. The load is then delivered to the elevator E. The elevator is built in a stout sheet-iron frame with ample supports for the guides of the buckets. It is manipulated by two strands of chain, in the centre of which the buckets are hung for the purpose of giving a perfect delivery, as shown in the illustration. The coal is discharged into hopper H, which is mounted on a turntable. Immediately beneath the hopper is the lower or feed end of an inclined elevator, the delivery end of which is so arranged that it can be raised or lowered, and so convey the coal into vessels which are to be supplied with bunker coal at any angle from the horizontal up to 45 degrees. To the delivery end of this elevator is attached a telescopic spout which can be swung round to accommodate itself to the hatch of the boats to be coaled. The whole apparatus, including hopper H, is mounted on a turntable, which gives every facility for directing the delivery shoot into any position. The motive power for this inclined elevator is provided by a separate steam engine C, which is mounted on the top of the turntable, and is thus able to operate the machinery thereon.

It will be seen that the delivery of the coal can be effected on either side of this coaling barge. There is also a second engine D, which is placed on the deck of the barge for operating the conveyor and elevator E, as shown. Both engines are fed from the boiler F. The unloading capacity is over 200 tons of coal per hour.

CHAPTER XX.

DISCHARGING OF RAILWAY TRUCKS.

THIS operation may be divided into two divisions, namely :—

1. Discharging by means of specially constructed self-emptying waggons or trucks ; and

2. Discharging by means of coal tips.

1. Self-emptying Railway Trucks.—Self-emptying railway trucks occupy a place of the first importance among labour-saving appliances, though British railway companies hardly appear as yet to realise their full importance. The commercial success of many an industry, and especially of that of the production of pig iron, depends to a great extent upon the efficiency and economy of the transport arrangements, and in this self-emptying trucks play a most important part.

The enormous saving to be effected not only by the adoption of self-emptying railway trucks but also by giving them a considerably increased capacity as compared to ordinary railway trucks, is demonstrated by the following figures. For instance, a steel-works receiving daily 200 truck-loads of ore and coal would, at a low estimate, pay for the unloading of each truck say only one shilling. This means a yearly expenditure for unloading alone of £3,000, but that sum could be almost entirely saved by the adoption of self-unloaders.

The following passage is from an article by Mr B. H. Thwaite, C.E., in *Page's Magazine:* "At an important conference of traders held in 1899, at Philadelphia, a statement was made by a speaker of great authority to the effect that if the Americans had no other advantage, that of economic railway transportation alone would ultimately give them supremacy in the manufacture of iron and steel, and that eventually they would have to supply the world." The accuracy of the speaker's forecast has been partly demonstrated. Whether it will prove to be absolutely prophetic depends greatly on British men of business themselves.

The following simple calculations will explain why American railway rates are low.

The dead or tare weight of a British standard waggon of 10 tons carrying capacity is 6¼ tons, so that for a load of 40 tons the dead weight of the waggons (British pattern) would be 25 tons. If the waggons have to be hauled empty on their return trip, the actual dead weight handled would be 50 tons. Therefore, a British train of waggons carrying 40 tons is handicapped with a dead load of 50 tons. But the American 40-ton self-unloading car would have a dead or tare load of only 14 tons. This would be doubled on the return journey, and would then be equal to 28 tons.

The advantage of the American system in the reduction of the dead load would be represented by the equation—

$$\frac{28 \times 100}{50} = 56 \text{ per cent.}$$

Thus for every million tons hauled on British lines the excess of dead load carried is equal to 560,000 tons.

Apart from the above weighty considerations, there is the great saving of terminal expenses incident to self-emptying trucks. When these American as compared to British methods are realised in the full measure of their importance, the lessening of the working costs of American railroads as compared with those of British railways can be no cause for surprise.

It is gratifying to know that British railway managers are at last realising the importance of reducing as much as possible, for heavy mineral traffic at any rate, the dead load proportion of their rolling stock. Some of the leading British railway companies are adopting, if somewhat cautiously, goods trucks of which the capacity and structure are modelled on American lines. It may be hoped that a large proportion of the trucks for bulk transit of raw material will be of the self-emptying type.

A factor which militates against the general adoption of large capacity self-emptying trucks for the carriage of coal, either consigned to ports or intended for inland consumption, is the height of the loading screens at some of the pits. The clearance is usually small, and an increase in height means that in many cases the waggons cannot be shunted under the screens to be loaded.

Another difficulty is this, that self-unloading trucks for coal, minerals, &c., are generally conveyed from mines to the manufacturing districts. Hence special trucks with hopper bottoms must generally be returned empty, as they are less suitable for the conveyance of ordinary goods. At ports, &c., where trucks are raised by tips, the existing cradles would in many cases be too small to admit them. In other cases the turntables are not of the requisite size. It will thus be seen that apart from the private ownership of 10-ton waggons, co-operation between the trader and the company is essential to the successful introduction of self-unloading trucks, and so far traders have been slow to recognise the advantages of this system, and are at least lukewarm in regard to the alterations of terminal plant which are essential. In many cases, again, the sidings are too narrow to admit the larger trucks, for though the wheel base may be the same as in the existing 10-ton wooden waggons, the truck is generally some inches wider. Thus it will be seen that at the coal ports some alterations in the loading appliances will be necessary before the general adoption of such waggons is possible.

The use of self-unloaders can of course only be beneficial in conjunction with other mechanical devices and suitable terminal plant for handling the material when unloaded. The most economical method of disposing of the contents of the truck is to raise the railway siding to a sufficient height above the point at which the material is to be unloaded to allow the latter to fall by its own gravity as soon as the self-emptying truck has been opened. In all other cases elevators with suitable feeding devices (which have been fully dealt with elsewhere) will be necessary.

The 15-ton hopper-bottomed self-discharging iron-ore waggons of the Alquife Mines and Railway Co. Ltd., which were built by Messrs Hurst, Nelson, & Co. Ltd., are of special interest. These waggons are used for conveying iron ore from the Company's mines at Alquife, in the South of Spain, to the shipping port of Almeria.

The Company have constructed a special pier at the latter place, and the waggons had to be specially designed to meet both the loading arrangements at the

mines and the discharging into the steamers. Owing to the very steep gradients which these waggons have to traverse on the South of Spain Railway Co.'s lines, a certain portion had to be fitted with brakesman's boxes, which are equipped with powerful screw brakes in addition to the vacuum brake. The waggons, 160 in number, are double hoppered, and are built entirely of steel. A special feature is the arrangement of bottom doors. Close attention has been given to avoiding the waste during transit of any ore, a portion of which is in the form of a fine powder. The principle of the door arrangement consists in the raising at the centre of a pair of V-shaped arms, which are attached to brackets riveted on to the bottom doors. The motion is transmitted by a cross shaft to a centre lever, which is in turn connected to the door arms by a separate lever which acts on a fulcrum. Suitable arrangements are provided at one side of the waggon to regulate the amount of travel of the doors, and also to secure them in the open and shut positions.

The waggons are fitted with side spring buffers, screw couplings and safety chains, and are quite equal to the class of rolling stock used in this country.

The self-emptying waggons of the North-Eastern Railway, built by Messrs Sheffield & Twinberrow, are for loads of 35 tons, the tare being 14 tons, or 40 per cent. of the paying load, as against 50 per cent. which is about the average of 10-ton waggons.

The Lehoen Pressed Steel Co., of Pittsburg, U.S.A., and the Pressed Steel Car Co., were probably among the first to build these cars largely of pressed steel parts. At the present time over 400,000 cars, the bodies of which have been built principally of pressed steel, are in use in the United States. These trucks are built with capacities of from 30 to 70 cubic yards; those from 30 to 50 are used for coal, while the largest, up to 70 yards capacity, carry coke. It must not be supposed that these steel waggons are more expensive than the old-fashioned wooden ones, or that they compare unfavourably when the capacity per ton is compared with the total cost. The wear and tear on the steel ones is also considerably less than in the case of wooden trucks.

The weight of a wooden truck of a capacity of 30 tons is 15 tons, whilst that of a pressed steel self-discharging truck of a capacity of 50 tons is 15½ tons. Thus, comparing two trains, one composed of the old-fashioned wooden cars, and one of the pressed steel unloaders, but both having a capacity of 1,500 tons, it is evident that in the former case thirty trucks of a total weight of 750 tons would be necessary, whilst in the latter case only fifteen waggons of a total weight of 462 tons would be required, which means that a saving of 288 tons dead weight is thereby effected.

The trucks are so constructed that the hoppers are only raised a few inches above the flaps of the shoots on the unloading staithes. Hence when the sliding doors are removed, the coal falls on the shoots with but little force, and thus the breakage between the waggon and the spout leading into the ship's hold is reduced to a minimum.

The Goodwin Coal Truck.—In Fig. 306 is shown an end view and cross section of the Goodwin coal truck, which has been adopted on several of the American coal carrying lines.

The body of the car is built upon two plate girder sills 21 inches apart. These girders are 18 inches deep at the middle, and 9¼ inches deep at the ends. The space between the sills is left clear for dumping the load between the rails, and from each sill there is an apron or floor inclining downwards. The two ends of the car are connected by top side plates 18 inches deep, and the car is divided in the centre by a transverse bulkhead, so that either of the two compartments can be dumped independently of the other. To the top side plate on each car, in each compartment, there is hinged a swinging door which, when the car is loaded, rests on the projection of a movable section

in the bottom of the hopper, which is composed of two narrow movable sections hinged to the longitudinal shaft. Each bottom section is held in position by a tripping device by means of which the said movable section on either side of the car may be released as it swings downwards, inclining towards the apron, thus releasing the swinging door and permitting the discharge of the load. The apron is hinged along its middle line longi-

Fig. 306. End View and Cross Section of Goodwin Coal Truck.

tudinally, so that the upper portion can be swung upward. When the upper section of the apron is set in this position and the swinging door released, the latter strikes against and is held by a spring on the raised portion of the apron, and the contents of the car are discharged between the sills and inside the rails of the track.

The dumping devices are arranged to be operated either by hand or by compressed

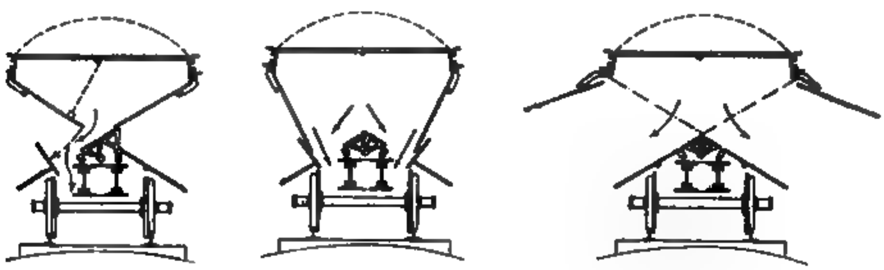


Fig. 307. Methods of Discharging with the Goodwin Self-emptying Truck.

air, hand dumping being accomplished by means of a wheel at the end. When equipped for pneumatic dumping, an air cylinder is attached to the outside end of the car in proximity to the hand wheel.

A few methods of discharging are shown in Fig. 307. The car is 35 feet 11 inches long over the end sills, 8 feet 10 inches wide over all, while the extreme height from top

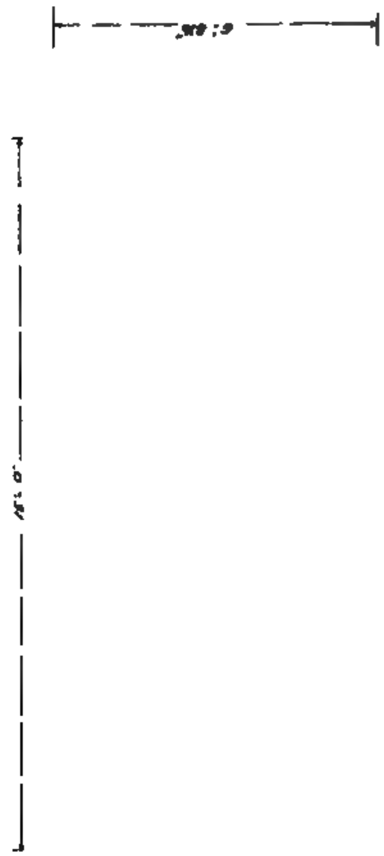


Fig. 308. Self-unloader of the London and North-Western Railway.

of rail is 8 feet 6 inches. The carrying capacity is 40 to 60 tons of ore, and with the load heaped it amounts to about 40 cubic yards.

Self-unloader of the London and North-Western Railway.—This self-unloader may be seen in Fig. 308, which shows one of these trucks in plan and two elevations. It is

principally built of wood, is hoppered, and discharges its load from two large outlets at the bottom of the truck, the discharge being effected by withdrawing a pin which

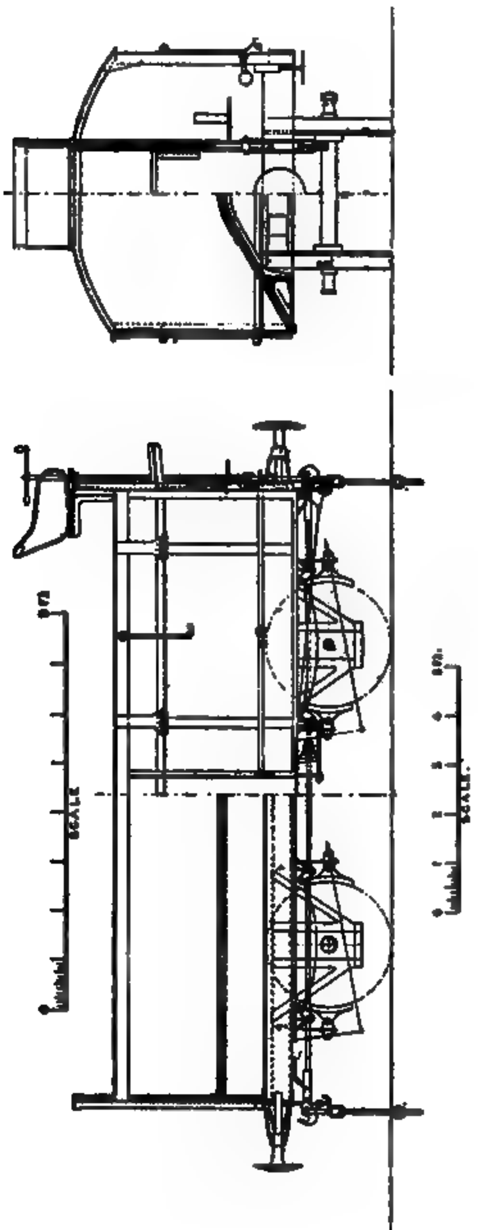


Fig. 310. Self-unloader of the Düsseldorf Eisenbahnbedarf.

releases the doors. Each outlet is really again divided into two halves, and in the cross section one half of the outlet is shown open.

All the other parts of the waggon are clearly seen in the illustration, and require no further description.

Ballast Waggons of the Great Western Railway.—A waggon of this type is shown in Fig. 309 in four views. These ballast trucks, though self-unloading trucks, have not been built expressly for the conveyance of coal or minerals. They were designed for the

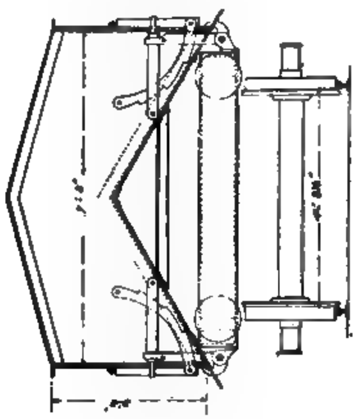


Fig. 311. Willich Self-unloader.

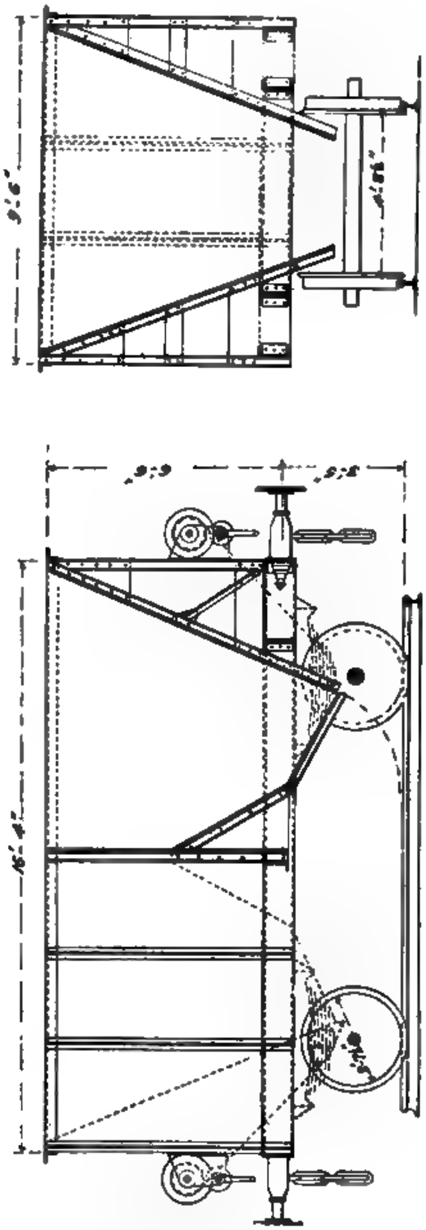
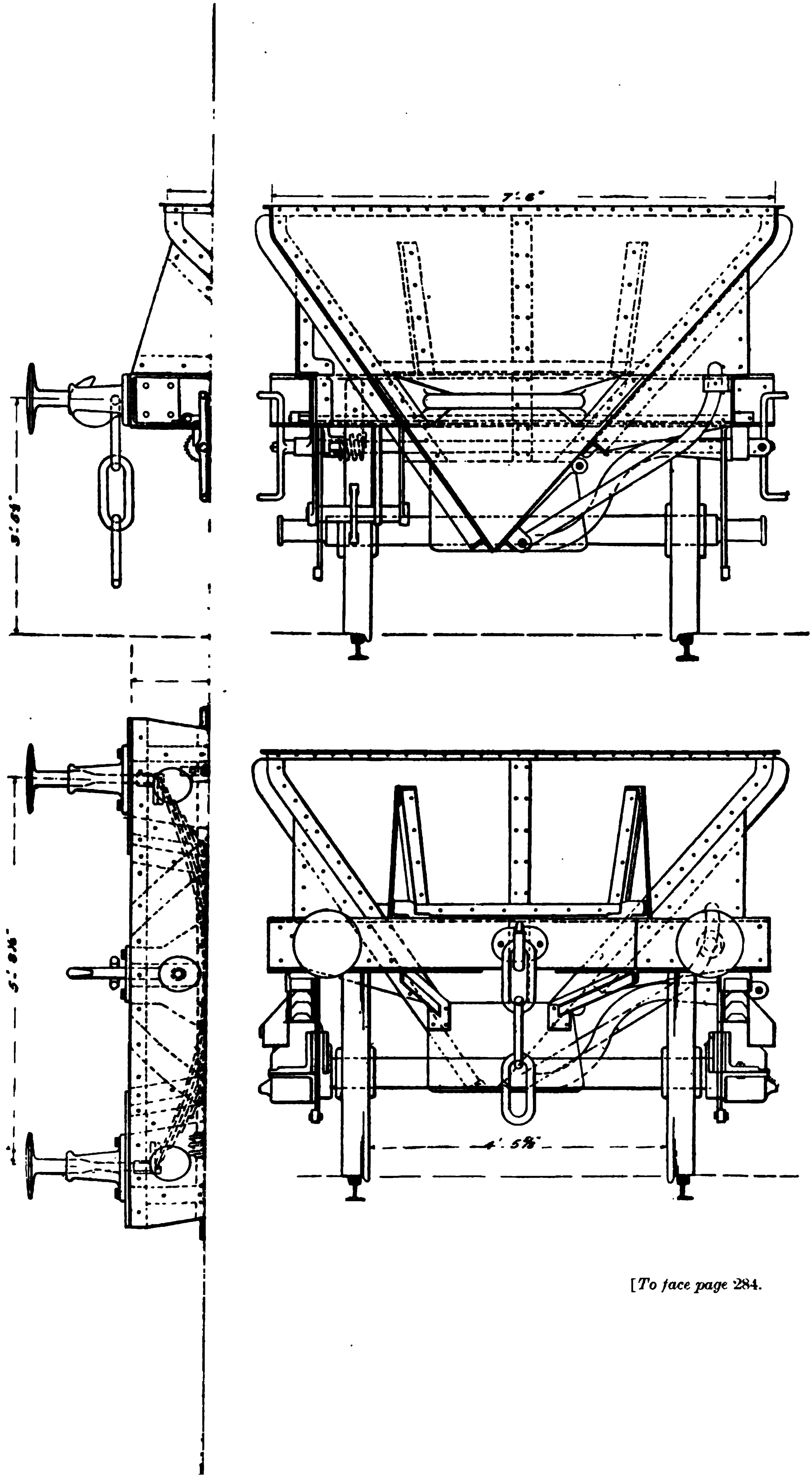


Fig. 312. Self-unloader of the Düsseldorf Eisenbahnbedarf.

purpose of depositing ballast on the permanent way. The operation of laying and spreading is effected as the train moves slowly forward, but there is no reason why waggons of this type should not also be used for the delivery of coal or minerals. The



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illustrations should explain themselves. The whole truck is hoppered and terminates in two large outlets. These waggons have been built in connection with the "Rodger's" ballast system.

The train containing these self-emptying trucks has a rear van attached to it with the plough. The nearest hopper to this plough is emptied first, the hopper in advance always being opened just before the preceding one is empty. The plough, following the trucks and being a rear vehicle of the train, spreads the ballast evenly, and leaves the road in a perfect condition for the traffic. The whole operation of spreading the contents of a train of fifteen trucks, containing about 180 tons of ballast, can be carried out in from eight to ten minutes.

In this system only two men (the brakesman and his mate) are required to perform the whole operation, which formerly required thirty to forty men, and occupied some hours.

Self-unloader of the "Düsseldorf Eisenbahnbedarf."—This unloader is unlike most of the other self-unloaders in so far as the discharge is effected on both sides of the rails, the truck being hoppered to both sides instead of being hoppered to the middle. Fig.

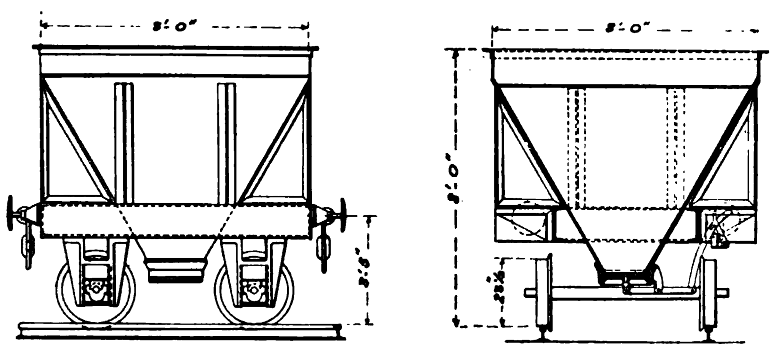

Fig. 313. Self-unloader for Liquids.

310 shows such a truck in plan and two elevations. This system is as adaptable to wide as to narrow gauge railways.

The under framing is of iron, while the upper portion is made entirely of angle iron and sheet iron lined inside with wood. The raised bottom is of wood with a stout sheet-iron covering. The side doors are hinged from near the top, and admit of a complete emptying of the truck, the doors being as wide as the trucks themselves.

The "Willich" Self-unloader.—This is illustrated in Fig. 311, and is very similar to that last described, the truck having a Λ-shaped floor, instead of a Λ-shaped floor with a rounded top. This truck is built by Willich, of Dortmund, and is used principally for sand, clinkers, &c.

Fig. 312 represents another truck principally used for the conveying of coal and coke. It is fully hoppered, and has a Λ-shaped partition in the centre to admit of two outlets, which are controlled from the end of the truck, and can be opened to any desired extent, the opening being correctly adjusted by means of a small winch. This truck was built by the "Düsseldorf Eisenbahnbedarf."

Self-unloaders built by Willich, of Dortmund.—Fig. 313 represents a special truck which is fully hoppered with one outlet. This is designed for the conveying and discharging of liquids such as slurry, slag, lime, &c., and has a capacity of 6 cubic yards.

The same firm also make a number of other trucks specially designed for different purposes. Figs. 314 and 314A show one of their special trucks for ore, coal, coke, slag, sand, &c. It is hoppered in both directions and fitted with two large outlets.

Figs. 315 and 315A show a truck specially designed for the conveyance of furnace

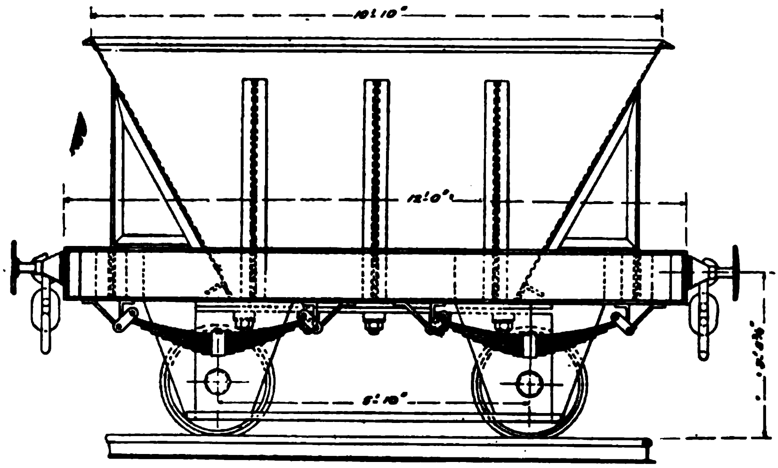

Fig. 314. Type of Self-unloader.

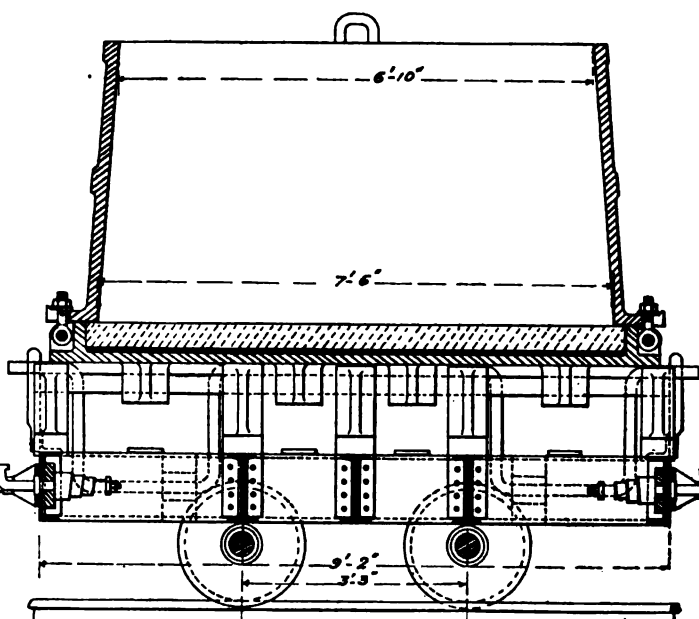

Fig. 315. Self-unloader for Furnace Slag.

slag. The illustrations represent the car in longitudinal and cross section, and explain themselves. The truck can be tipped by pushing the fastenings to one side, and the slag is discharged together with the top portion of the truck. The latter is afterwards

picked up by the crane and put back into position. The sides of the car being tapered, the slag readily leaves the truck.

The Nossian System of Quick Unloading Railway Trucks.—This system may be mentioned under this heading, although the trucks are not absolutely self-unloading.

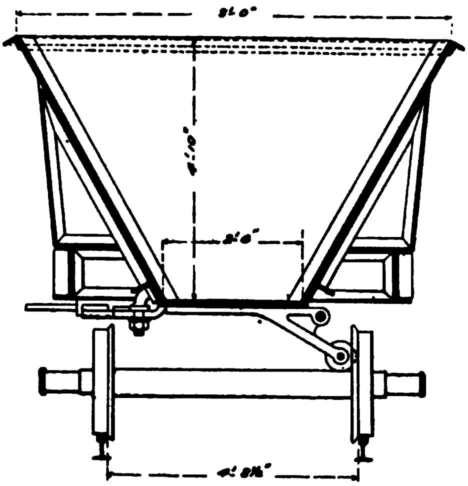

Fig. 314A. Cross Section of Unloader.

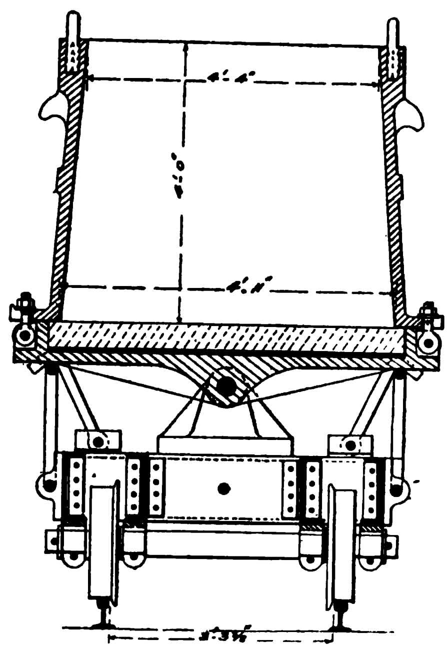

Fig. 315A. Cross Section of Unloader.

They are used by several Continental firms, and are built by the Allgemeine Oesterreichisch-Transport-Gesellschaft, of Vienna, and also by the Wagonfabrik Aktien Gesellschaft, of Cologne.

The unloading is effected by the upper portion of the truck being made movable, by means of racks and pinions, and worm and worm wheel. The whole of the upper portion of the truck is pulled to one side and the contents thus unloaded.

Fig. 316 shows such a railway truck in plan and three elevations. In the end view the two cranks which are worked by two men are seen. The crank spindle is fitted with two worms which engage with two small worm wheels; these are keyed to a spindle which also carries two pinions. The latter engage in tooth racks fitted to the framework, and thereby push the whole upper portion of the truck to one side, so that the contents, or at least four-fifths of them, can be unloaded, while the remainder can be quickly removed by hand. The arrangement is such that unloading can take place at either side. It is claimed as a great advantage that this truck is to all intents and purposes an ordinary railway truck, and can at the same time be used as a self-unloader.

The time occupied in unloading is from five to seven minutes, and the whole operation, including the reinstallation of the upper portion of the truck, may be

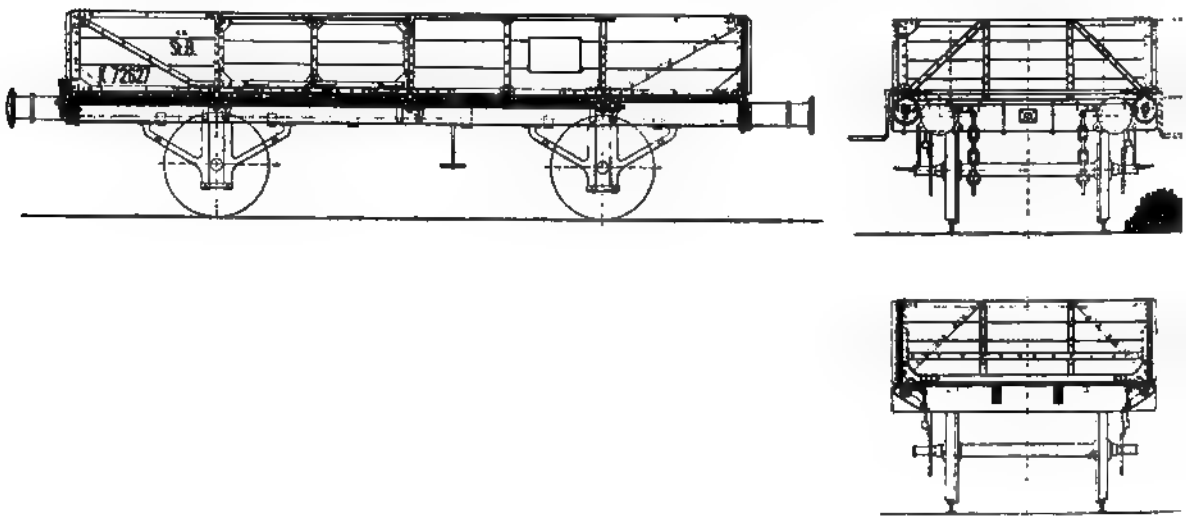

Fig. 316. Self-unloaders on the Nossian System.

performed in from ten to twelve minutes. Two men are sufficient for the work, and considerable saving of time is effected by the use of this truck, as it may be reckoned that two to four men would take one to two hours to empty a railway truck by hand, according to the nature of the material.

Self-unloaders on the Baden State Railway.—Railway trucks on the same system, which are, however, slightly hoppered on both sides, and thus entirely dispense with hand labour, are in use on the Baden State Railway.

One of these trucks is illustrated in Fig. 317 in four views, which explain themselves. It will be readily understood that the body of the car need not be moved so far to one side as in the construction previously described, because as soon as the hoppered portion reaches the edge of the bottom of the truck, the car will be empty.

This truck has a capacity of 18 tons. The under frame is generally of iron construction, whilst the upper portion is usually of wood.

The "Lidgerwood" Rapid Unloader.—This can hardly be called a self-emptying

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Fig. 318. Winch of Winding Gear of the Lidgerwood Unloader.

railway truck, because it does not discharge automatically like the trucks described in the previous pages. The trucks used are flat bottomed, and their contents are discharged by mechanical means not unlike those just described.

This appliance is used on a complete train of flat-bottomed cars, the spaces between which are bridged over by steel aprons hinged to the end of each truck. By means of a cable and a plough the whole of the trucks are mechanically emptied. It is claimed that this system of handling ballast is more economical than any other. To begin with, the whole train is loaded by a steam navvy, and the train of carriages is one continuous trough without any divisions. The mechanical device for manipulating the plough is illustrated in Fig. 318, which shows the compound geared winch winding engine, made in two sizes, namely for 25 and for 60 tons pull.

The trucks used are 39 feet 8 inches long by 8 feet 9 inches wide inside, the sides being 3 feet high. The doors are hinged from the top so as to swing in an outward direction. Twelve such cars were loaded in thirty minutes on one of the American lines, and over 4,000 cubic yards of material have been handled by the steam shovel and train per day.

The cost of filling such cars on the Kansas City Southern Railway, U.S.A., for the months of March, April, May, June, and July 1900, is stated to have amounted to 2·89 cents per cubic yard, or about $1\frac{1}{2}$d.

Fig. 319 gives a full view of the unloading mechanism, which is built for 25 tons pull.

The illustration shows the way in which the steam supply from the locomotive boiler is taken to the engine of the winch, the pipe being fitted with flexible joints to allow for any movement or vibration.

In Fig. 320 the loaded plough may be seen at work unloading a train. The winding gear near the locomotive engine can also be seen in the distance.

Fig. 322 gives a side view of the same unloader. In the latter case the side boards of the trucks have been entirely removed, but in other installations on the same system the sides may be composed of five doors hinged from the top, through which the ballast is expelled.

This device is the design of the Lidgerwood Manufacturing Co., of New York.

The "Hunt Automatic Railway."—A practical method of carrying heavy material, such as coal and iron, from wharf-side or railway to the stock heaps or storage bins, is the "Hunt automatic railway," operated entirely by gravity, no mechanical power or manual labour being required. The salient point of this system consists in the sufficiency of energy which is acquired by the loaded car descending an inclined track. This energy is utilised, after the discharge of the load, for returning the empty car to the place whence it started. A similar principle is in use on certain ropeways, where a sufficient incline can be utilised to secure the energy required for the automatic return of the buckets or skips.

Automatic discharge is by no means exclusively utilised in connection with railways in the ordinary sense of that word. As will be made clear in the following pages, the automatic discharge of heavy material, whether carried in trucks on rails, or in buckets on steel ropes, can be readily effected at any desired point by a variety of devices which will be duly described in their respective places.

In the "Hunt" system, the car, however, rests not on ropes, but on rails. The coal or ore when unloaded from the boat is deposited in the car by the attendant. Only one man is needed to operate the railway. He loads the car, but its further progress is automatic. It runs down the track, discharges its load at any predetermined point, and then returns empty to the starting point.

Fig. 319. The 25-ton (Pull) Lidgerwood Unloader Engines.

The attendant does not accompany the car. The time taken in making a trip of 300 feet, dumping the load, and returning it to the starting point, is about fifty seconds. As the loaded car approaches the end of its trip it raises a counterbalance weight to a certain height by means of a steel wire which the car picks up while running down the track. After the load has been discharged, which, as has already been explained, is an automatic action, the impulse received from the car and given up by the drop of the counterbalance weight is quite sufficient to drive back the empty vehicle up the track to the starting point. The weight only rises a certain height, the object being to give the car a start back, its own momentum carrying it the remaining distance. It is important that the raising of the weight should form a gradual movement, in order to minimise to the utmost any strain of the various parts of the mechanism.

Fig. 321 shows the details of such a plant at work at the Avonbank Electricity

Fig. 320. Rear View—Loaded Train with Plough.

Works, Bristol, erected by Messrs Babcock & Wilcox Ltd., English agents of the C. W. Hunt Automatic Railway Co. A general drawing of this installation will be found facing page 430.

The ordinary method of discharging these cars is by opening the sides by means of a tripping block placed on the track, so as to let the load out on both sides. The bottom of the truck has a ridge in the centre, so as to run the material clean out (see Fig. 323).

The sides are fastened, not to the car, but to each other. Thus if one is unfastened, both are open. The load is always evenly discharged, and there is practically no risk of the car overturning, though the gauge is a very narrow one. These cars are built of wood and are lined with sheet steel. They are provided with self-lubricating bearings, rubber springs and steel axles. The bearings are of a peculiar construction, and are so arranged that the car will run round a curve of 30 feet radius with practically the same ease as on a straight line. The gauge of the truck is 21 inches from outside to outside

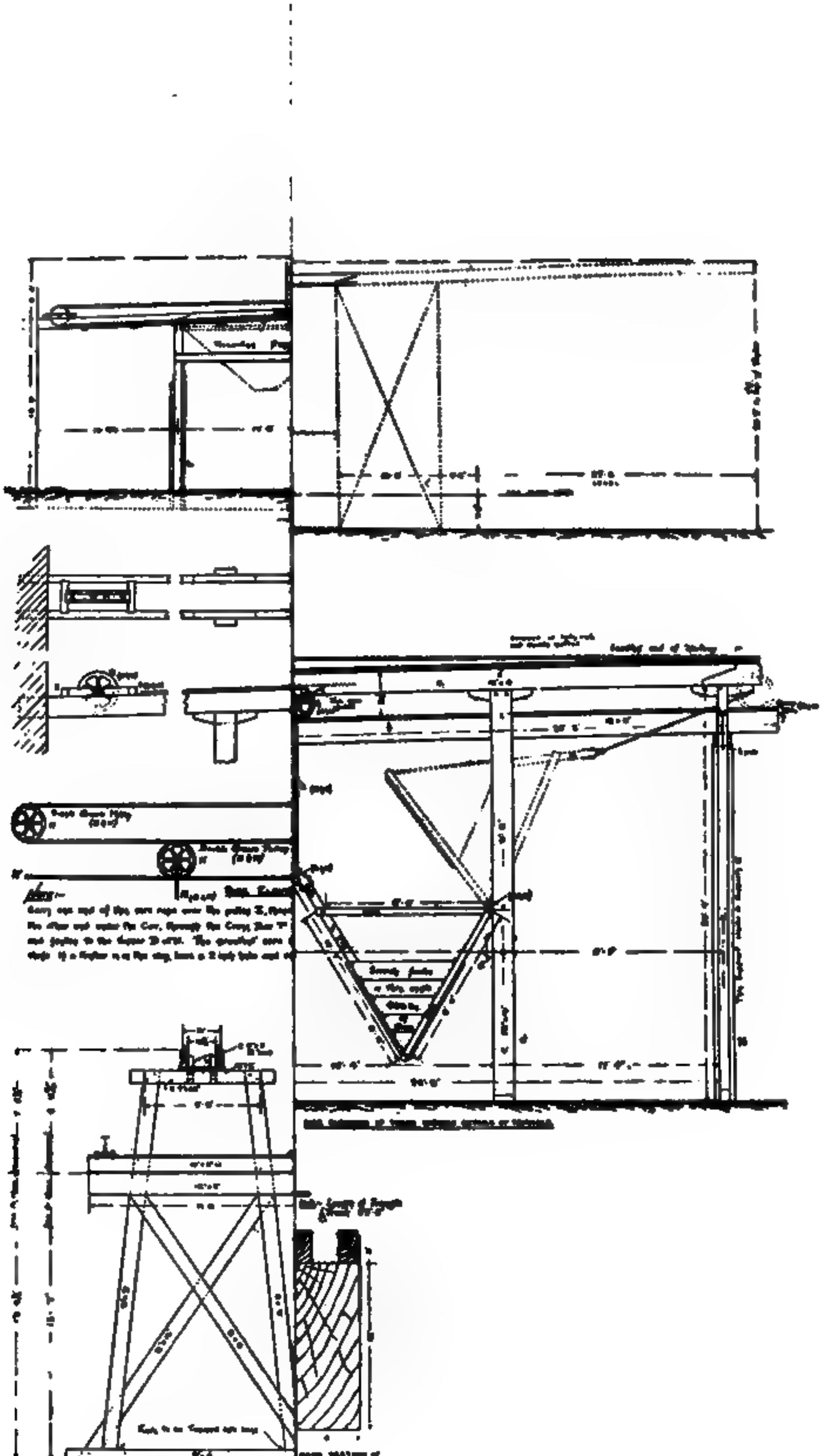

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Fig. 322. Plough passing over Apron.

of rail heads. The steel wire rope that raises the weight is detached from the car except during the time that the car is raising the weight and receiving the impulse to return; curved tracks are possible, but should be as near the feeding terminus as possible; they require special rails to suit the flexible running gear used on these cars. All material received over the railway can be weighed by placing platform scales in the track at the loading end. The attendant who loads the cars can at the same time also weigh the loads, and enter the weight in the tally book, as the car is running down the track. On account of the width of the car, and owing to the distance to which the side doors open out, the scale beam must be further away from the centre of the platform than usual. If desired, automatically registering weighing machines may be used, for description of which see pages 383 to 409.

The "Hunt" automatic car is built in two sizes, the smaller carrying 1 ton, and the larger 2 tons. This appliance has been chiefly used for handling coal, but it is equally suitable for other heavy material, such as ore, phosphates, clay, &c. The construction of the truck, including the shape of the base, is varied according to the nature of the material to be conveyed.

Amongst "Hunt" automatic installations may be mentioned one at the Story Coalyard, Brooklyn, New York, where two cars on separate tracks distribute all the coal hoisted by a 2-ton grab to a pocket which holds 7,000 tons.

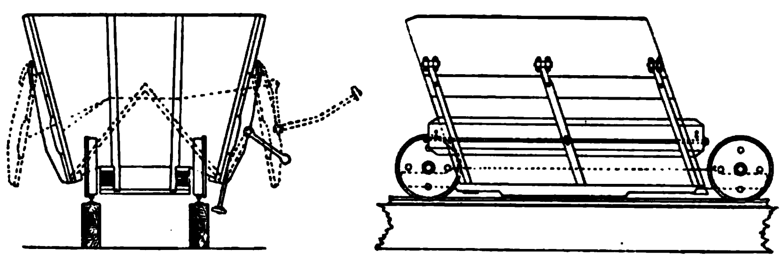

Fig. 323. Truck used for Hunt's Automatic Railway.

The Calumet and Hecla Mining Co., Lake Linden, Michigan, U.S.A., use five 2-ton cars which run on twenty-seven automatic tracks. The "Hunt" system may also be seen in operation in Dublin, where it is used by the United Tramways Co. At Ludwigshafen, on the Rhine, it has been installed by the Westfaelisches Kohlen-Syndicat, also at the Gas-works of Zürich, which latter plant was erected by Pohlig, of Cologne.

The origin of this device is somewhat curious. The first "Hunt" automatic railway was built in 1871, and seems to have been brought into being by a strike of coal wharf operatives. Where this first railway was erected is not recorded, but doubtless it was in or about New York, the home of the C. W. Hunt Automatic Railway Co.

The principle of this automatic car is very simple, but the conditions under which it is used vary widely. For instance, it may be made to serve the largest coalyard by means of many separate tracks converging on one or two points. The track or tracks may be placed at any height, and if desired, the car may be made to dump from an elevated track at any given point, so as to build a pile of coal in the storeyard. The track on which the car runs may be carried by a movable bridge (controlled from the hoisting tower), which will itself serve a wide area. The Lehigh Coal and Iron Co.'s wharf at West Superior, Wisconsin, U.S.A., is 2,000 feet long and 300 feet wide. It is equipped with nine movable elevators and seventy-five "Hunt" automatic railways. The unloading capacity of this plant amounts to 7,000 tons per day.

Bulk Transit of Grain.—The bulk transit of grain has been brought to great perfection in the United States, and there is no doubt that in this country some progress has been made amongst the larger inland flour millers. It may freely be admitted, however, that to many mills in this country the bulk transit of grain would be of little or no use, but on the other hand there seems to be a large field for its adoption in granaries and merchant mills of fair capacity, of which the inland position makes the mechanical handling of material (at least at the terminals) a matter of vital importance.

The mills that may fairly dispense with the bulk handling of grain are at the two ends of the scale, namely, the small country mills, to which grain is brought in farmer's carts from the immediate neighbourhood, and the large port mills, which receive foreign wheat either directly from ocean-going steamers at the quay-side or from barges that have been loaded in bulk or with sacked goods from the ship. One of the strongest arguments in favour of the bulk transit of grain is the saving in terminal charges which the general adoption of such a system would be likely to bring about. Under present conditions no doubt railway companies may fairly argue that it would be unreasonable to ask them to reduce terminal charges whilst only a fraction of the larger merchant millers of the kingdom have adopted the system. The possible economies of the bulk system of grain handling are well illustrated by a comparison of the freight rates between Chicago and New York and between Liverpool and Manchester.

Taking the rates current at the close of year 1902, the rate per ton between Chicago and New York amounted to about 15s. 6d. for about 800 miles, while the rate per ton between Liverpool and Manchester on a haul of 31 miles amounted to 6s. 11d. Thus it will be seen that the rate on the long haul amounted to about one-fifth of a penny per ton per mile as against 2¾d. per ton per mile on the short haul. There is no question but that railway freights for grain are excessive in this country, generally speaking, and although in this as in other problems many factors enter into the composition of the rate, yet it is clear that the handling of grain in sacks tends to keep up the high rates. One of the lowest rates for grain current in England is probably that which is in force between Hull and Newcastle, where 7s. 6d. per ton is charged on a haul of 110 miles, equivalent to about eight-tenths of a penny as against one-fifth of a penny for 800 miles haul in the United States.

It is easy to understand why the bulk handling of grain is likely to effect great economies in transport. The labour bill is considerably reduced, and as covered trucks are used, no waterproof sheets have to be provided, while the item for labour in connection with these sheets is also saved. Moreover, considerably less shunting is required with the bulk system of transit for this reason, that the space occupied by a 7-ton truck loaded with sacks will not be exceeded by a 20-ton bulk car.

When grain is handled in bulk, much greater loads can be carried in a single train. For instance, the average train load on the Pennsylvanian Railway is 484 tons, as compared with the 68-ton load of the London and North-Western Railway. The heavier load no doubt postulates greater engine power; but if this item in the working expenses is somewhat increased, a considerable economy can be effected at the terminal points, not only in the saving of labour but also in the handling of the rolling stock, because a 500-ton train will not require a larger working staff than a 150-ton train.

At a moderate calculation, the general adoption of the bulk system, with self-emptying railway trucks, in this country, would enable the railway companies to reduce their terminal charges by at least 33 per cent. According to *Milling*, a journal to which thanks are due for many facts in connection with this important question, "No

miller can realise the full economy to be obtained from the bulk handling of grain unless he has his own siding."

To show how wide reaching are the economies possible with a well-organised system of bulk transit, it may be noted that the difference at most of our ports between the overside and the quay rate amounts to about 7d. per ton. Under the present system of sack handling the miller is often compelled to buy *ex* quay, whereas with a reasonable track-to-car rate millers whose grain was handled in bulk would be able to buy *ex* ship. Moreover, the petty pilfering which goes on more or less where sacks of grain are handled would be rendered well-nigh impossible by the use of bulk cars, which could be sealed or locked, thus reducing the liability of shortage to the lowest minimum.

Amongst British millers who have already adopted the bulk system of grain handling are the Scottish Co-operative Wholesale Society, at their Chancelot Mills, at Leith, and Messrs Watson, Todd, & Co., of Birmingham. Perhaps one of the best examples now to be seen in England of bulk grain handling is afforded by the Industrial Co-operative Society's Mills, at Leeds. The bulk of the wheat used in these mills is bought at Hull, and is conveyed in the Society's boats to a transit silo on the banks of the river Aire. This installation may be considered a receiving station for the mill's raw material. Up to 1st December 1902, 157 boats had been unloaded here, and 66,000 quarters of wheat had passed through the silos, not to speak of a large quantity of other kinds of grain. Two bulk cars are continually passing between the mill and these transit silos, taking wheat away as fast as the boats are unloaded. These cars were built by the Society's own workmen, and have a carrying capacity of 5 tons each. The method of loading and unloading is most simple. The roadway passes right under the silo bins, and as the bulk cars are drawn in at one end of the building they can be rapidly loaded and passed out at the other end. By a simple lever arrangement a slide is opened in the hopper of the bin from which it is required to draw wheat, and in two minutes 5 tons of wheat have entered the car. Then the slide is promptly closed and the car passes on its journey to the mill. It is alleged that not more than three minutes are required for passing the empty car into the silo warehouse at one end and taking it out loaded at the other end. On arrival at the mill the cars can be unloaded with a minimum of labour by a simple tipping device, receiving hopper and elevator. The latter lifts the wheat to the top of the mill, where it is passed over two warehouse separators which deliver into the storage bins. Not more than two and a half minutes are, it is said, required for unloading each truck.

There is no doubt that before the bulk handling of grain can come into general use in this country it will be necessary to devise a thoroughly practical form of truck. The first cost of such rolling stock would soon be recouped by the undeniable economies incident to this system. So far as the author is aware, but one railway company, the Lancashire and Yorkshire, have provided cars of their own design for this particular traffic. These cars have a length over head stocks of 35 feet, and a width of 8 feet. The inside height at the sides is 6 feet 1 inch, and at the centre 7 feet 1 inch. The capacity is 1,563 cubic feet. The wheel base of the bogies is 5 feet 6 inches, with 25 feet between bogie centres. They have a carrying capacity of about 30 tons of wheat, but have been criticised by millers on account of the large amount of trimming that is required before they can be entirely emptied. It is, by the way, alleged that this particular design was a sort of compromise between the purely bulk grain car and a truck that might be used for other kinds of merchandise which are carried on this particular line, such as cotton. What is required is a truck of large capacity that can be securely fastened, so as to prevent tampering with the loose grain, and will automatically discharge at its

destination without the necessity of hand trimming. Messrs Spencer & Co. Ltd., of Melksham, have built a truck for carrying loose grain which is provided with a hoppered bottom, but if it be desired to use this truck for sacked goods, a flat floor can be laid over the hoppers. In adapting the bulk system to the conditions current in this country, it should always be borne in mind that the immense loads of grain which are carried over the main trunk lines of the United States would be out of place in Great Britain, where flour mills are on a much more modest scale than the giant merchant mills which are to be met with at certain points in the winter-wheat, and especially in the spring-wheat belt of the United States. Again, but few of the dock companies of the United Kingdom are prepared to handle bulk grain, that is to say, to load bulk cars. The Manchester Ship Canal Co. has, however, provided automatic scales and loading shoots, by means of which loose grain can be weighed and shot into trucks adapted for this traffic. The Manchester grain silo and elevator are well provided with railway sidings, being connected with every railway system running into Manchester, so that here are to be found all the elements for a rapid extension of this system of grain handling on the railways of Lancashire, Yorkshire, and of the Midlands. All that would seem to be required are more convenient bulk cars, which the railway companies should provide, and tipping pits or hoppers to receive the grain in bulk from the flat-bottomed cars which are tipped to empty, or from hopper-bottomed self-emptying trucks, which should be provided by the owners of sidings where grain is received in bulk trucks for the service of either flour mills or granaries.

Hopper-bottomed trucks are to be preferred on account of their quicker discharge. Unfortunately such trucks would not be of much good for other purposes. The author would suggest covering the wide end of the hopper with an iron grating composed of flat iron bars with a mesh of 2 to $2\frac{1}{2}$ inches. This grating could be used as a floor for the reception of sacks. The mesh would not be too open to walk upon, and the grating would not be in the way when filling or emptying loose grain.

CHAPTER XXI.

UNLOADING BY MEANS OF COAL TIPS.

THE coal tips which are hereafter described are classed under three headings. Each of these three different types of tips is suitable for three different purposes, mainly depending upon local conditions, such as the height of the railway siding or quay above the water level in the port, river, or other destination of the material to be unloaded. The three types of tips are the following :—

A. Tips which unload below the level of the railway lines.
B. Tips which unload on the same level as the railway lines.
C. Tips which unload above the level of the railway lines.

A. **Tips which Unload Below the Level of the Railway Lines.**—It is obvious that the operation of unloading trucks for the purpose of depositing the contents below the rails can be performed without the expenditure of power, as the weight of the coal itself is sufficient to tip the truck, and to use the inertia either directly or after being stored in accumulators to right the truck after emptying.

The following are a number of examples of coal tips of this class :—

The Old Newcastle and Cardiff Tips.—The old Newcastle and Cardiff tips are here described from a historical point of view. They have done good work in the past, but are now generally superseded by tips of the hydraulic type. They are only applicable where the trucks are on the wharf at a high level, or where the railway lines are raised on staithes, from which elevation the coal is deposited by gravity down the shoot into the vessel. The waggons are hopper-bodied and self-discharging, or else are end-tipped into the shoot.

In Newcastle the former method is more often used, and in Cardiff the latter.

These balanced tips consist of a suspended cradle or platform A, Fig. 324, sliding in vertical guides, and are supported by balance weights BB connected to them on either side by chains passing over pulleys CC at the top of the framing, upon which are brakes D for controlling the motion of the cradle. The balance weights are sufficient to raise the cradle and empty waggon, but are not equal to the load when a full waggon is upon the cradle. The waggons D are discharged through an end door into an inclined shoot E extending over the ship's hatchway, and sometimes having screens at the bottom for separating the dust from the coal. The brake is then released, and the cradle with the empty waggon rises to the top again, the waggon is run off into a siding, and the cradle is then ready to receive another waggon. Crane N and lowering device P are employed in order to minimise breakage.

By the use of tips of this construction, a height of 9 feet is lost by having to lower the cradle sufficiently to tip the waggon. A gradual increase in the size of the ships to be loaded rendered it necessary to prevent this loss of height in the tips, in order to

raise the shoots to the level required by the increased height of the decks of the ships. Instead of lowering the cradle, therefore, the tail end is hauled up by a winch worked by hand, thus converting it into a tip discharging on the level of the rails instead of below. This tedious process was subsequently superseded with great advantage by a hydraulic lift, consisting of a simple Armstrong crane cylinder with a 9-inch ram and double pulley connected to the tipping chain. This system has been adopted in reconstructing the old balance tips at both the west and east docks at Cardiff. The first balance tips constructed at the west docks received the waggons on the cradle at a level of 18 feet above

Fig. 324. Balanced Tip of the Old Cardiff Type.

the quay, but the increased size of the ships to be loaded has necessitated raising the railway level and the framing of the tips 3 feet higher, making the level for the waggons at the west dock 21 feet above the dock coping or 22 feet above the water. The coal tips at the east dock were originally constructed at this higher level, but in consequence of such large vessels being unloaded there, the height of the additional tips constructed has been further increased by 6 feet, giving a height of 27 feet above the coping.

As it is necessary to adjust the level of the shoot to the actual height of each ship,

in order to reduce breakage of coal as much as possible, the heel of the shoot is attached to the frame of the tip so as to slide in a vertical groove. The shoot is carried by adjustable chains with balance weights and winches, so that the inclination as well as the height of the shoot can be changed if necessary.*

Hydraulic Tip at Dortmund.—A hydraulic coal tip of some interest is at work in the harbour of Dortmund in Germany. It is on the Schmitz-Rohde principle, and was built by Friedrich Krupp, Grusonwerk, Magdeburg. This tip consists essentially of a platform swinging on a horizontal axis. The coal trucks are pushed on this platform and tip with the latter, emptying themselves over the end into the barge. The apparatus works without the expenditure of outside power, so that there is no necessity for a motor. The principle is to utilise the energy due to the weight of the contents of the truck when lowered, and to store it in an accumulator, to use again for raising the platform and truck when the latter is empty.

This is a great improvement on similar installations in which this energy is lost by absorbing it in a brake, as in that case motive power must sometimes be provided for

Fig. 325. Plan of Coal Tip at Dortmund.

lifting the truck. The tip can be used for the rolling stock of all the lines which are likely to bring coal or coke to the harbour of Dortmund, and for loads of 10 to 15 tons the only condition being that the trucks are fitted with hinged end doors. Figs. 325, 326, and 326A illustrate the tip. A is the platform which swings round the trunnion G. The forward end of the platform is suspended by the hydraulic ram F of a movable supported cylinder B. To the other end of the platform a balance weight is attached. The cylinder B communicates by means of a pipe with an accumulator D, the connection between the two being controlled by a valve and manipulated by a lever C, and in the control of this valve lies the whole manipulation of the tip.

The action of the tip is as follows:—

As the truck is being pushed on the platform its two front wheels depress two levers, which action releases two strong hooks that hold the axle of the front wheels. This is seen in Fig. 325. The hooks and the levers manipulating them are concealed

* This description is taken from a paper read by Mr John M'Connochie, before the Inst. Mech. Eng. See Proceedings Inst. Mech. Eng., August 1874, pages 125 to 130.

below the platform when out of use, and do not therefore interfere with the brake tackle under some of the trucks. The truck and the levers holding the same are coupled to the axle of the platform, not rigidly, but by means of volute springs to reduce the impact.

The truck is allowed to move into a position in which its centre of gravity is on the waterside of the centre of the platform. The weight of the load causes a pressure in the cylinder B of about 300 lbs. to the square inch. The pressure in the accumulator is, however, only about 255 lbs. The valve is now opened, and as there is a difference in the pressure of cylinder and accumulator of 45 lbs. to the square inch, the truck pushes the ram into the cylinder, thereby lowering the platform, and the truck begins to discharge. During the tipping process the centre of gravity of the truck alters its position in such a way as to increase its leverage. The momentum of the load does, however, decrease as the load of the truck is getting less. At the angle of 45 degrees the platform and truck have reached their maximum travel, at which the latter is empty. The speed of the descent can be regulated by throttling the communication between hydraulic piston and accumulator by means of lever C, which is closed altogether as soon as the lowest position is reached.

The coal as it leaves the truck falls into a shoot which forms an extension to the platform, the sides of which, to prevent waste, are somewhat higher than the truck. The end of the shoot can be so adjusted as to let the coal fall gently into the ships or barges which are to be loaded. As the load on the ram F becomes less towards the end of the operation, the pressure is reduced to about 210 lbs. When the valve is now reopened the surplus pressure in the accumulator is sufficient to raise the platform into its original position. The valve is manipulated by a lever C over the accumulator on that part of the structure which is not movable. From the same spot a second lever can be used which actuates another valve which allows the water to escape from the cylinder B to the open, in case the load in the truck should not be sufficiently heavy to force the water out of B into the accumulator. As the momentum increases during the tipping process, the valve must be closed almost immediately after the platform has begun to descend in order to economise the pressure in the accumulator. Finally, there is a safety valve which opens automatically in case of extreme pressure in cylinder B through the valve having been closed too soon. This valve admits the water into the accumulator. The plant is provided with a hand pump which is used when the cylinder and accumulator are first filled, and also to replenish any loss through leakage, and also in cases where the cylinder B has to be relieved into the open as stated above. A mixture of glycerine and water is used in the apparatus to prevent freezing.

It takes five men to manipulate the tip. One operates the valve and lever C, two are placed in the shoot and go up and down with the same to regulate the discharge by means of two small winches, whilst two push the trucks on and off the platform.

As the goods station is on the same level as the quay wall, the coal train is taken up such an incline that there is a slight fall from the point about half-way between the platform and the tip, so that the trucks run down by their own gravity to the latter. They pass a turntable on their way to and from the platform of the tip.

The Coal Tip at Ruhrort Harbour.—This is very similar to the tip just described, and has also been built by Krupp, of Magdeburg. It is illustrated by a longitudinal and cross section in Figs. 327 and 328.

Two perspective views of the same are given in Figs. 329 and 330. The construction is almost identical with that of the tip at Dortmund, and needs therefore no further description.

A similar appliance to the last mentioned is the work of Rudolf Dinglinger, of Coethen, Germany. It is illustrated in Fig. 331. This plant acts almost precisely in the same manner as the last. The valve and hand wheel, which are visible in the illustration, break and open the communication between the hydraulic cylinder and the accumulator, the latter not being shown. This device is intended for unloading coal in factory yards and disposing of it by elevator either into the coal stores or into the overhead bunkers over the boilers. In many cases it is advisable to provide such a tip with a coal-breaker between the hopper and elevator.

The tipping arrangements just described have this advantage over the next, that they are absolutely automatic as far as the expenditure of motive power is concerned,

Fig. 326. Longitudinal Elevation of Tip at Dortmund.

whilst those to be described in the next paragraph require force pumps to manipulate them, but the conditions under which they were installed warranted their adoption.

Coal Tips at Bethune. Unlike the tips previously described, which tip and empty themselves on a transverse axis, the tip of the Compagnie des Mines de Bethune turns on a longitudinal axis. The installation, which is illustrated in Fig. 332, was erected some time ago for the purpose of quickly discharging coal, brought from the Marles Colliery, at a small expenditure of driving power. As will be seen from the illustration, the quay wall, which has been constructed by the Marles Colliery Co., is at a sufficient height above the water level to allow of a discharge from the quay to the barges by gravity. This automatic tip is the design of Messrs Taza & Villian, of Annezin. It consists essentially of a substantial platform having a frame of wrought iron, which supports a portion of a railway track of standard gauge. Loaded trucks are pushed on this platform, and then a very small expenditure of power is necessary to set the tip in

motion, whereupon the coal should be set rolling until it is deposited in an inclined shoot, which leads, by means of an additional piece of spouting, to the river. As soon as the coal has been discharged, the tip returns with the truck to its original position, when the truck is pushed off the platform by a new and full truck. This process is an exceedingly simple one, but, as in the case of the appliances previously described, some precaution should be taken to prevent a shock, and also to provide for an automatic return of the tip to its original position. To this end a hydraulic brake has been constructed in conjunction with a balance weight. This brake consists of a cast-iron cylinder, 16 inches diameter, which is erected beneath the platform within the quay wall. A piston which fits the cylinder is connected with the platform of the tip by a connecting rod. Both ends of the cylinder are connected to the hydraulic main, the outlets being controlled by valves. Thus when the platform is being lowered during the discharge of

Fig. 326A. Cross Section of Tip at Dortmund.

the contents of the truck, the piston forces the water out of the cylinder, and by regulating the outlet by means of the above-mentioned valve, the process of lowering can take place without shock. The return movement of the platform to its level position is controlled by the balance weight. The truck with its load of 10 tons of coal is pushed upon the platform, which is, by the way, supported upon two trunnions 8 inches in diameter, which are placed slightly out of centre with the platform so as to give it a natural inclination to sink towards the waterside. The balance weight consists of two weights secured by rods to the lower portion of the platform in the same way as a pendulum. The total weight of the two is 5 tons, or somewhat more than the weight of the empty truck. As soon as the load has left the truck there will be a tendency for the counterweight to replace the platform in its original position. When starting the tipping operation the counterweight will only balance the weight of the truck, but will have no other influence upon the action of the tip.

During the return of the platform, the hydraulic cylinder and piston are again

brought into action to prevent a too quick return of the platform, and thus avoid shock. The railway trucks are specially constructed for this particular purpose, and have

Fig. 327. Longitudinal Elevation of Tip at Ruhrort Harbour

Fig. 328. Cross Section of Tip at Ruhrort Harbour.

hinged side doors for the discharge of the coal instead of end doors, as in the tips previously described. These doors can be opened by means of a lever suitably placed at one end of the truck. The whole load of 10 tons is discharged into a spout which

is of sufficient capacity. The outlet of this shoot is so contracted as to let the coal out into the barge in a gentle and more or less uniform stream.

It is generally so arranged that the same time is allowed for the coal to empty itself out of the shoot into the barge as it takes to bring back the empty truck into its original

Fig. 329. Perspective View of Tip at Ruhrort Harbour.

position and replace it by a full one. A number of capstans have been erected at the quay by means of which the barges can be quickly put into position for loading. One man is sufficient to operate the tip. Two such tips are now at work at Bethune, and as each is capable of dealing with twenty-five trucks of 10 tons each per hour, 5,000

tons per day of ten hours can be handled, and a speed of five waggons in ten minutes has been accomplished. These tips have the undoubted advantage that the empty

Fig. 330. View of Tip at Ruhrort Harbour in an Unloading Position.

trucks can never be in the way of the full ones, as all trucks, both full and empty, are moved in the same direction, and on the same road.

A device similar to the Bethune coal tip was erected by the Société Charbonnière,

of Lens;* also by the Bruay Mining Co., Calais,† in connection with their loading basin at the north of Bethune. The capacity is rather less than in the case previously described, as it will only handle seventy waggons of 10 tons each per day.

The Noeux Co.'s Tip.—This device, which is again similar to those just described, is illustrated in Fig. 333. It has been used at the dock of the Noeux Co., in connection with the canal of La Bassé à Aire.

There is a fixed hopper or frame formed of two ribbed cast-iron cheeks solidly bolted to the wall of the wharf, on which is fixed a crane for handling the movable shoot. This movable shoot is connected to the fixed hopper by a spout which can be turned in any position around a vertical axis, and distributes the coal over the area thus commanded.

The trucks are of special construction, and their bodies consist of three boxes of a capacity of 3½ tons each, which are tipped separately.

Fig. 331. Tip for Power Stations and Factory Yards.

On the side next the hopper the boxes are provided with doors hinged horizontally at the top, and engaging in clips which are fastened a little back upon the ends of the car. At the bottom of this door two pins are fastened which work laterally, and are caught when the box rests on the truck by two dogs attached to the sill.‡ With this arrangement, when the box is raised from the back, the pins on the door are gradually set free from their dogs, and at a certain point the door becomes unfastened and opens for the

* A description of this arrangement will be found in the *American Engineer and Railroad Journal*, February 1894, page 70.

† This appliance was described in the *American Engineer and Railroad Journal*, March 1894, page 112.

‡ A description of this arrangement will be found in the *American Engineer and Railroad Journal*, March 1894, page 112.

passage of the coal. On the return, when the box is empty, it drops back on the under frame, the pins catch under their dogs, and the door is fastened. At the Noeux station the boxes are raised by means of a hydraulic ram, whilst at the loading wharf they are manipulated by an ordinary crane.

Coal Tip Built by Pohlig.—Another device which comes under this heading is that built by J. Pohlig, of Cologne, and illustrated in Fig. 334. It will be seen that immediately in the rear of the tip is a turntable, by means of which the waggons are put into the right position to enter the cradle, the railway line being parallel with the quay. The truck is held in position by means of a chain at the tail end, whilst the front buffers rest against a support specially constructed for this purpose, so as to take the weight without straining the buffer springs. Like other similar appliances, this tip is only suitable for

Fig. 332. Tip at Bethune.

trucks with hinged end doors. Unlike the tips previously described, the one in question is manipulated by means of a band brake. The end of the cradle is weighted so as to bring it back to its original position when the truck is empty. The band brake is of such power that the truck can be held in any required position. The tip is also fitted with a hand winding gear to be used if, in exceptional cases, the truck should not go back to its original position.

The Stevenson Coal Tips.—Fig. 335 shows such a coal tip in two elevations. This tip is manipulated by gravity, and requires, therefore, no driving power. The mode of working it is to run the truck on to the tip, which is kept in a horizontal position by means of a powerful brake. The position of the truck is such that its own weight will overbalance it as soon as the brake has been released. After the discharge of the truck, it returns automatically into its original position. It is fitted with a shoot which can be

raised out of the way when not in use, or the angle of which can be adjusted to suit the circumstances.

Fig. 336 represents another type of Stevenson's coal tip very similar to that first

Fig. 333. The Noeux Co.'s Tip.

Fig. 334. Tip Built by Pohlig.

described. The illustration shows the appliance in plan and elevation, and the tip is shown, in the latter view, in its horizontal as well as in its discharging position. This

Fig. 335. Example of Stevenson's Coal Tips.

particular tip is arranged so as to overhang the quay wall, in order to get the discharge of the tip right on to the barge to be loaded.

Fig. 337 shows a further development of the Stevenson tip. The illustration consists of a longitudinal elevation and two cross sections, one through the tipping portion and the other through the framework extension The appliance is arranged in such a way that it can be racked in and out. The whole apparatus is mounted on a

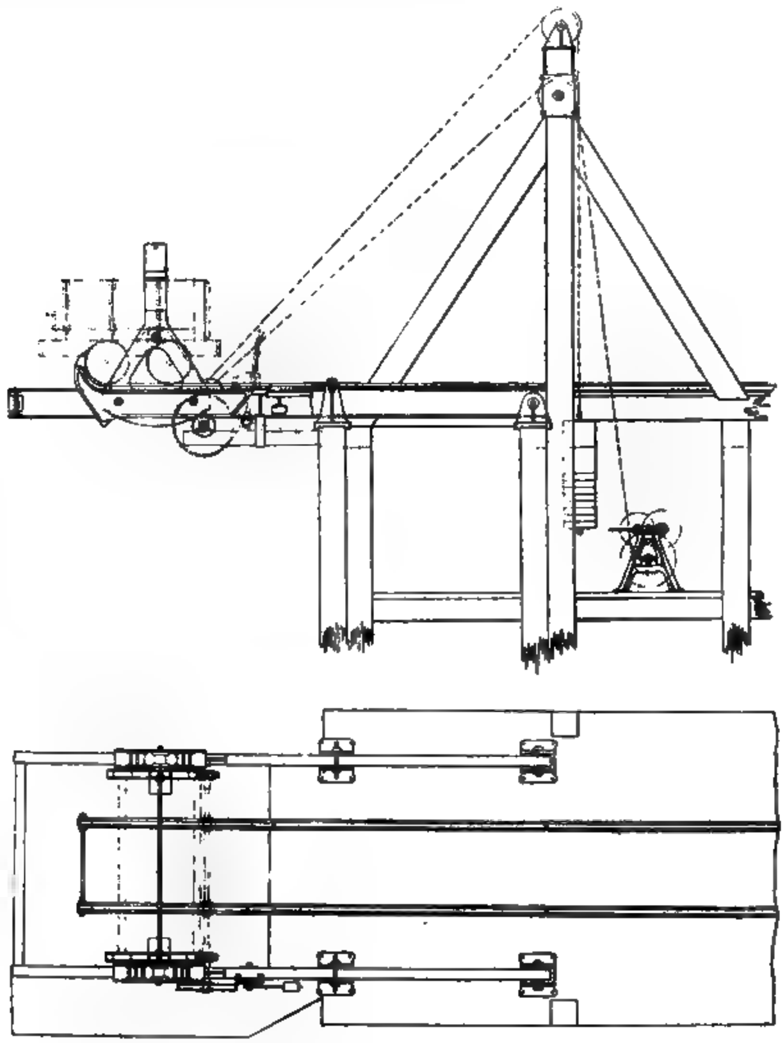

Fig. 336. Plan and Elevation of Stevenson's Coal Tips.

framework consisting principally of two long girders, so that the apparatus can be pushed in and out so as to overhang the quay wall more or less, but in all other respects the tip is the same as Fig. 335.

B. Tips which Unload on the same Level as the Railway Lines.—Tips of this description are manipulated by raising one end of the truck in order to

Fig. 337. Longitudinal Elevation and Cross Section of Coal Tip built by Stevensons Ltd., of Preston.

unload it, the reverse process having been followed with the tips previously described. There one end was lowered beneath the level of the rails for the discharging process, which allows of unloading with practically no expenditure of driving power. Tips that unload on the same level as the rails must in all cases be actuated by hydraulic or other power.

The Power Tips of the Great Western Colliery Co., Pontypridd.—The annexed illustration, Fig. 338, is the design of Mr Davison, Engineer of the Great Western Colliery Co., Pontypridd. It shows the apparatus in a longitudinal and cross section. The trucks to be emptied by this tip must be provided with hinged end doors.

The main feature of this tip is that it can be operated by a motor or by a belt from any existing shaft. The rails remain unbroken, and the apparatus can be used without interfering with the traffic on the siding. It is evident that there are many cases in which such a tip can be used with great advantage. It will be seen from the

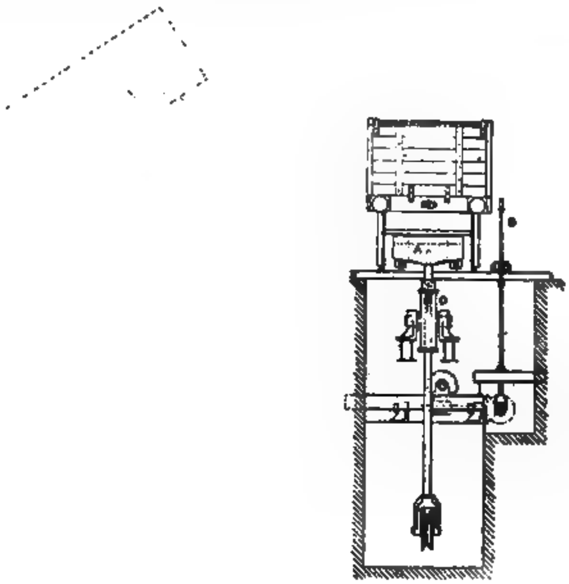

Fig. 338. Tip in Use at the Great Western Collieries.

illustration that the rear axle is brought over the ram-head A when the lever B is thrown over, which causes the friction clutch to engage with the worm shaft actuating the drum, and thus winds the chain which lifts the ram. Radial rods C are fixed to the ram-head and prevent the truck from moving out of its position during the lifting process. The ram passes through a cast-iron sleeve D with trunnions guiding it in the course given by the radial bars. When the truck is tipped the lever is removed to the opposite side. This causes the reversal of the gear and the consequent lowering of the truck down again to the rails. The time occupied in tipping the truck is about one minute.

Tip at the Brentwood Gas-works.—The installation illustrated by Fig. 339 is at work at the Brentwood Gas-works, and as the coal is taken in there at the rate of only 10 tons, or one truck-load, per hour, the slower working tip answers the purpose quite as well as one fitted with a more powerful pump, and consequently having a quicker action.

The hydraulic lifter and pump were built by the Leeds Engineering and Hydraulic Co. Ltd. The pump is a very small one, and is always at work when coal is being unloaded.

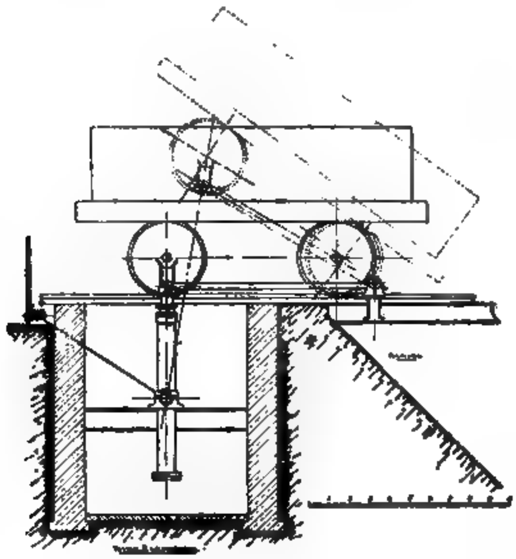

Fig. 339. Tip at the Brentwood Gas-works.

This does not cause any waste of power, as the water only circulates between pump and tank. When the truck is ready to be tipped the water from the pump is forced into the hydraulic

Fig. 340. Hydraulic Tip built by the Leeds Engineering and Hydraulic Co. Ltd.

cylinder by turning a lever which controls a valve, when the ram slowly lifts the back portion of the truck off the line, whilst the front wheels rest against stop blocks. The coal begins to discharge from the removal of the tail-board till the truck has been lifted

to an angle of 45 degrees. To lower the truck on the line the water is allowed to escape from the cylinder into the tank out of which the pump is fed. This can be done slowly by carefully opening the valve.

Another Installation by the same Firm.—Almost the same device as the previous one is illustrated in Fig. 340; it varies principally in this, that the hydraulic cylinder is pivoted from the lower end instead of from the centre.

Coal Tip of Pohlig.—A tip of this type, but of more cumbersome design, is built by Pohlig, of Cologne, and is shown in Fig. 341. The platform is pivoted at its fore end, and is raised above the level of the ground by hydraulic force applied to its centre. The truck of course moves with the platform until it is tilted at an angle of 45 degrees, at

Fig. 341. Coal Tip as Built by Pohlig.

which angle the rest of the material is discharged into the hopper or other receptacle on a level with the line. To minimise to the utmost the expenditure of power, the weight of the platform is balanced by counter weights. In other respects this platform is designed exactly on the plan of the cradle used in the other automatic tipping devices built by the same firm, which are described elsewhere.

To prevent a sudden drop of the heavy platform and its truck, which might happen if some portion of the gear was accidentally to give way, this tip is provided with a safety brake which holds the truck and platform so that in case of breakage it cannot move either up or down any faster than its normal speed.

The "Rigg" Coal Tip.—This tip is the design of Mr James Rigg, and is under the

control of a brake, gravity being utilised as motive power. It has been applied with success to the tipping of end-door railway trucks, and two of these machines supplied to the West Bank Dock, near Widnes, are working with good results.

This machine is illustrated in Fig. 342, end elevation; Fig. 343, plan; and Fig. 344A, side elevation.

The oscillating platform of this machine is strongly constructed of wrought iron, and is so balanced that all trucks of medium length when placed on the machine tip it forward and automatically put in motion, under control of the brake, the projecting spout or shoot parallel to the floor of the waggon, which conveys the coals into the hatch, thus not only avoiding the intervention of a second shoot, but materially reducing the breakage which occurs in the passage of coal from a truck when otherwise tipped above the ordinary adjustable shoots. Though a fair average may be determined as to the length of the coal truck, and this tip is so balanced as to suit it, it is obvious that in the few cases in which trucks may be found extremely long or correspondingly short, gravity will act in one direction only, and in such cases the winch shown in the two illustrations may be used to complete the operation of tipping.

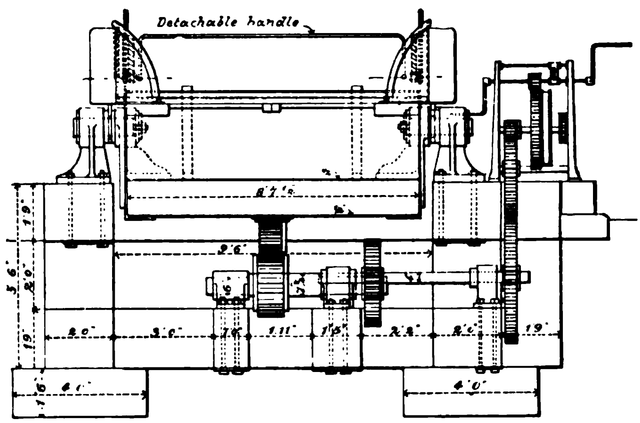

Fig. 342. End Elevation of Rigg's Coal Tip.

The machine illustrated is used chiefly for loading small coasting vessels, and to give increased facilities for changing hatchways, the projecting shoot is balanced and arranged to rise as shown in Fig. 344, which also gives in a separate outline diagram the relative position of shoot and vessel.

The capacity of these machines is necessarily limited by the pace at which the cargo loaded can be trimmed in the hold. Were it otherwise, the average performance of 1,000 tons per day of ten hours could be exceeded.

C. **Tips which Unload Above the Level of Railway Lines.**—The tips under this head are undoubtedly the most important of the three types, and are generally used in cases where a quay wall is not very high above the water level, or where large ocean-going steamers (the holds of which naturally extend above the level of the quay) have to be loaded with coal and other minerals.

It is obvious that in this third type of tips a great expenditure of power is necessary, because not only has the coal to be lifted to a level considerably above the quay walls, but the truck itself has to be lifted bodily with the coal.

The first mechanical coal tips of this description were lifted and tilted by hydraulic

power. Such coal tips are still the most generally used, but electrically driven tips are beginning to be introduced on the Continent. It may be said that the loading of coal ships has called into use a greater variety of hydraulic appliances than almost any other operation in the mechanical handling of material. The credit is undoubtedly due to Lord Armstrong, one of the pioneers of the hydraulic system, whose firm, Sir W. G. Armstrong, Whitworth, & Co. Ltd., have always been well to the front in building hydraulic tips for loading vessels. It must be admitted that no fixed rule can be laid down as to the type of machinery to be employed in each individual case. A great deal must depend upon position and local conditions. This applies not only to the various systems, but also to the various types of hydraulic machinery.

Sometimes direct-acting cylinders below the cradle are the most suitable, whilst in other cases hydraulic cylinders at the side of the structure manipulate the cradle by means of cables or chains as the case may be.

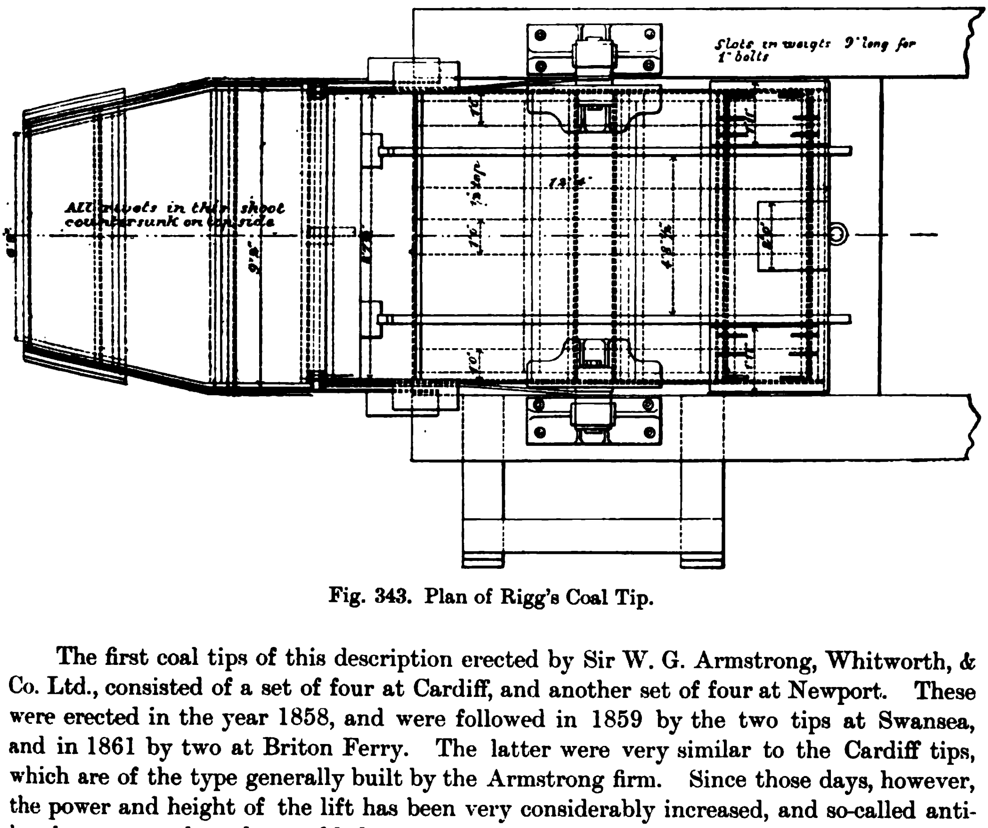

Fig. 343. Plan of Rigg's Coal Tip.

The first coal tips of this description erected by Sir W. G. Armstrong, Whitworth, & Co. Ltd., consisted of a set of four at Cardiff, and another set of four at Newport. These were erected in the year 1858, and were followed in 1859 by the two tips at Swansea, and in 1861 by two at Briton Ferry. The latter were very similar to the Cardiff tips, which are of the type generally built by the Armstrong firm. Since those days, however, the power and height of the lift has been very considerably increased, and so-called anti-breakage cranes have been added.

The Cardiff Tip.—The general type of the first Armstrong hydraulic tip and hoist is shown in elevation in Fig. 345, whilst Fig. 346 gives a plan of the same. Tips of identical construction are now being built with a lift of 40 feet and over above the quay.

The cradle A which carries the waggon is raised by vertical hydraulic ram B, whilst the cradle itself being guided at its four corners by the framework, the loaded waggon is raised to the level of the shoot E. The upper portion C of the cradle forms the tipping frame, and is pivoted at the front and tipped with the waggon upon it by means of a

second hydraulic cylinder D below the cradle, and attached to it as shown in Fig. 345. The cylinder oscillates on trunnions to follow the motion of the tipping frame, the hydraulic main being connected to the cylinder through one of the trunnions.

The whole apparatus can be controlled by a man standing on a side platform F, at the top of the framing, with the levers controlling the machinery close at hand. The raising and lowering of the shoot E for adjusting both height and inclination are automatically effected and are quite independent of hand labour. Two short arms project at each side of cradle A under the top end of the shoot. When the cradle is elevated the shoot is also carried up with it to any desired level, and is held in that position by weighted pawls, which fall into vertical racks secured at each side to the frame. By holding these pawls disengaged from the racks, the shoot may be lowered with the cradle to any desired level. The shoot is also secured by a safety chain on each side, which is fixed in each new position by a clip.

The two arms that lift the shoot are so balanced as to hang vertically and clear of the shoot when out of use, but when required they are thrown into action by pulling a small chain. The end of the shoot can also be raised or lowered in a similar manner, so as to give a greater or lesser fall, by means of two chains carried over pulleys at the top of the framing, and brought down the centre, one at each side, where they are secured to the frame by clips at the desired level. Whenever it is desired to shift these chains they are pushed upon strong hooks fixed at the edge of the cradle, and then by lowering or raising the cradle the point of the shoot is raised or lowered as desired, and the chains are again fixed in a new position by the clips. In some districts, South Wales for instance, where the coal is very friable, it is found necessary to take special precautions for reducing the loss by breakage which occurs in discharging the coal waggons into the

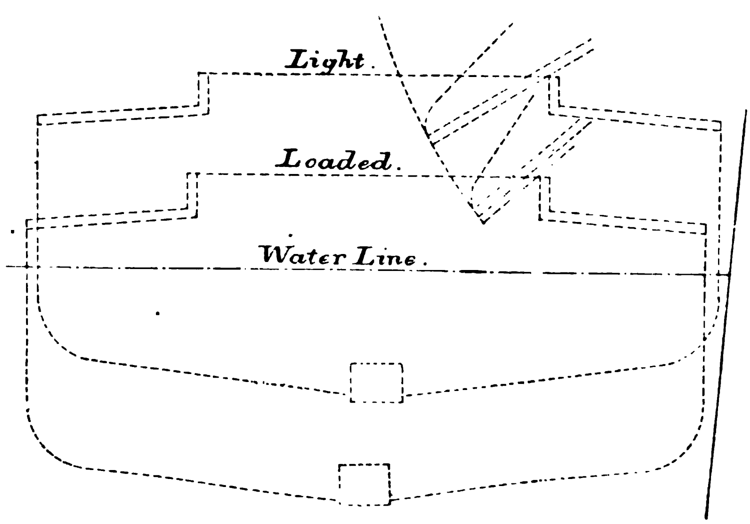

Fig. 344. Position of Barge and Shoots.

ship's hold, and for this purpose the anti-breakage crane N has been introduced with great success. For the latest development in this direction see description of the Penarth tips (page 337), in which full details of the Thomas Anti-breakage Box are given. The receptacle used in conjunction with this crane N is the iron skip P, holding about 1 ton of coal. It is hopper-shaped, with a hinged flap door for discharging at the bottom, and is

suspended from an independent light jib crane N, fixed at one side of the tip frame, and having hydraulic lifting and turning motions. In commencing to load a ship, this bucket is filled from the shoot E, then lowered to the bottom of the hold, and there emptied by pulling up the bolt which secures the flap door. This process is repeated until a conical

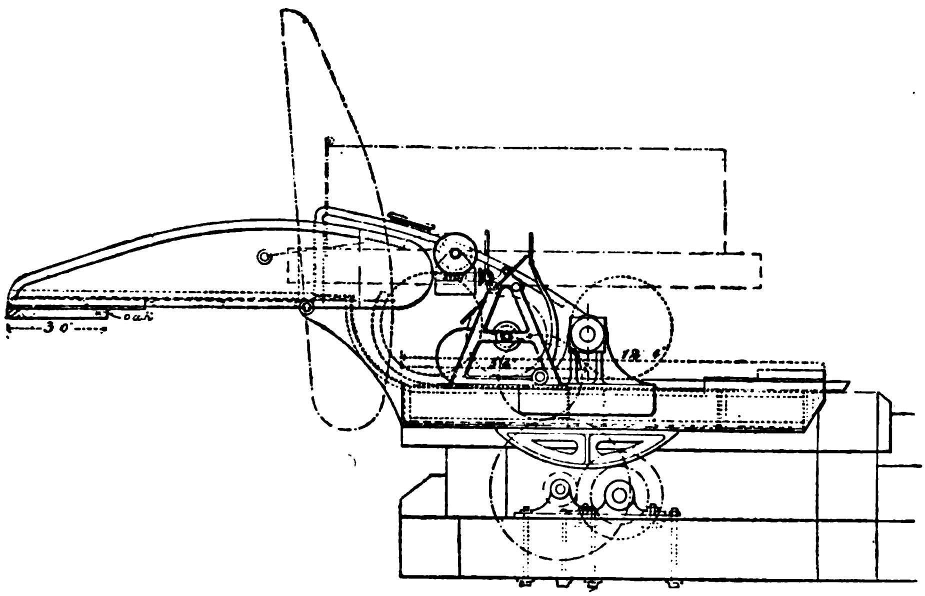

Fig. 344A. Side Elevation of Rigg's Coal Tip.

heap of coal is formed sufficiently high to reach nearly to the hatchway, after which the shoot is allowed to discharge freely without the use of the bucket and delivers close down upon the heap, a vertical drop being thereby prevented. The point of the shoot is somewhat contracted so as to check the speed of the coal down the incline. At this point the discharging sometimes requires a little assistance by hand, and is thus kept under control whilst the bucket is being filled. The whole process is effected much quicker than it takes to describe it, the discharge of the bucket in the ship's hold being self-acting, as the bolt which holds the flap door is fastened to a chain which is fixed to some portion of the rigging or deck, and thus the door is automatically released as soon as the bucket has reached the point of discharge. This anti-breakage crane is also used with advantage for discharging ballast, as well as for filling into waggons the small coal that passes through a screen sometimes fixed in the shoots. Notwithstanding all these precautions, the proportion of dust found in the coal when the ships are discharged at the end of the voyage is generally very great. This breakage is undoubtedly partly due to want of care in trimming the coal in the ship's hold.

Hydraulic Tips at the Barry Docks.—Another hydraulic tip with a direct-acting ram is illustrated in Figs. 347 and 348. It is the design of Sir John Wolfe Barry, and was erected by Sir W. G. Armstrong, Whitworth, & Co. Ltd. at the Barry Docks. This hydraulic coal tip consists of a substantial wrought-iron framework supporting the shoot, for conveying the coal into the hold of the vessel, and at the same time serving as carrying guides for the lifting cradle on which the coal waggon is raised to the level necessary for discharging into the shoot.

The cradle itself is manipulated by two direct-acting cylinders and rams, having a lift of 37 feet, these being placed below the cradle as shown in Fig. 347. One of these rams is so proportioned as to balance nearly the whole weight of the cradle, and is in constant communication with the hydraulic main. The action of this ram is somewhat similar to a balance weight. The water which is forced into the cylinder during the lifting of the cradle is returned to the main during the lowering.

The function of the second ram is to lift the load and the unbalanced portion of the cradle. There is a third ram working in an oscillating cylinder attached to the rear of the cradle for tipping the upper portion of the cradle which is pivoted at the water-side, and by which the discharging of the coal through the end door is effected. The water pressure for this tipping cylinder is taken from the main-lifting ram, the action being similar to that of the preceding tip. A load of 19 tons can be lifted and tipped. The tips were originally fitted with anti-breakage shoots to reduce the breakage of coal while passing down the shoot, but these were some time ago replaced by ordinary shoots fitted with a single door at the point of discharge for controlling the flow of the coal.

The adjustment of the shoot at the proper level and the housing of it when out of use is effected by the cradle itself, the front of which carries levers for taking the weight off the heel of the shoot in raising or lowering it. In the same way the delivery end of the shoot can be raised or lowered by chains which can be connected to the cradle when necessary. On one side of the framing is a hydraulic anti-breakage crane, with a box of a 3-ton capacity, similar to the crane previously described. The whole manipulation of the tip is effected by hydraulic cylinders in the usual way, and all machinery is adjustable to suit any conditions. The hoist and crane valves are all operated by a man standing in an elevated cabin on one side of the hoists (see Fig. 348).

The tips illustrated in Figs. 349 and 350 are also the design of Sir John Wolfe Barry,* and were built by Sir W. G. Armstrong, Whitworth, & Co. Ltd. for the Barry Docks. The principal difference between these tips and the one last described is that no part of the machinery is below the quay level. The two lifting cylinders below the cradle in the previous tip are replaced in the present case by four direct-acting cylinders, two on either side of the cradle. They are contained in box girders which also form the guides for the cradle. The lift in these tips is 37 feet, and the guides extend some distance above the top of the framing. The anti-breakage crane is for a load of 2 tons, and is in other respects similar to the last described. The tips are so arranged that they can at any future time be converted into movable hoists should this be desirable. A couple of tips, similar to the last, have since been erected at the Alexandra Dock, Newport, Mon. They have, however, a lift of 3 feet more than the previous one, or 40 feet in all. The capacity of these tips is about 300 tons of coal per hour. For working the waggons to and from the tip, Armstrong's capstans of 1 ton hauling power are used.

Coal Tips at Rotterdam.—The port of Rotterdam, from which a large proportion of the coal from the Westphalian coalfields is shipped, had long experienced the want of a simple and efficient coal tip. The traffic in coal for export as well as for navigation purposes had grown enormously. The annual tonnage, which did not amount to 50,000 tons in 1890, had in 1900 grown to nearly half a million tons.

The first tip was built more or less on the lines of the tips in use at English ports. The work was entrusted to Sir W. G. Armstrong, Whitworth, & Co. Ltd., and the tip erected in 1887 did most satisfactory work. It was driven from the existing hydraulic

* *Engineering*, 22nd March 1896.

mains at the harbour, which are under a working pressure of 900 lbs. to the square inch. The tip was for trucks holding 10 tons of coal, and designed for a lift of 33 feet.

Shortly after the starting to work of this tip the increased traffic rendered it necessary to double the capacity, and a second tip was ordered from the same firm, this time for trucks holding 15 tons and for a rise of 40 feet, the latter to be accomplished in thirty-six seconds. Fig. 351 is an illustration of this tip.

The two tips sufficed to cope with the traffic until about 1898, when they were working almost day and night, and it was decided to erect a third tip. As the hydraulic power in the harbour was taxed to its utmost limits after the erection of the second tip, it was decided to drive the third coal tip by electricity.

Fig. 352 illustrates the first hydraulic tip at the port of Rotterdam. This tip is suitable for all four-wheeled trucks used on lines that terminate at or have connections with Rotterdam. The framework is principally constructed of rolled girders, but wood is also used. P represents the cradle or stage for the reception of the trucks to be discharged.* It is suspended from four chains at C and D, and is actuated by the hydraulic rams xx', the former of which has a larger diameter, with four sheaves h and l, and works downward, whilst the latter x' is smaller, works upward, and is fitted with only two sheaves g. The chains which are connected to the stage P, at C, are guided over the chains $efgh$ to the hydraulic cylinder, and are attached at point E. Other chains lead from D to F over the sheaves *ikl*.

When the stage is in its lowest position, and the hydraulic ram x is forced down, the stage moves upwards, as all four chains are tightened equally through pulleys h and l. When the stage has reached the level of the discharge shoot, the water is shut off at x and turned on at x', which has the effect of lifting the stage from point C by the chains passing over pulley g, and so tilting the stage to a slanting position, which discharges the truck. The stage is then levelled again, by allowing the water to escape out of x' and then out of x, so that it drops by its own gravity. The stage is operated from point H, but there is an automatic stopping gear at the highest and lowest position of the stage, actuated by the rod s. The weight of the stage itself is balanced by the weight Q, which hangs on a chain, the two ends of which are attached to A and B, and pass over the sheaves *abc* and d. TT are two points from which the discharge of the trucks can be observed, and helped by hand if necessary.

A small crane with skip K is also provided for lowering coal in smaller quantities from the large shoot, as already mentioned, for preventing breakage of the coal. The chain is manipulated by the hydraulic cylinders y, and the sheaves u and v. It is further guided over pulleys *gvst*. For the side movement of the crane an additional hydraulic cylinder Z is provided. The hydraulic pressure which works the tip is 750 lbs. to the square inch. This is sufficient for ordinary trucks, but when trucks of 15 tons capacity have to be tipped, the pressure can be increased to 900 lbs. per square inch.

The Electrically Driven Tip at the Harbour of Rotterdam * is the design of Mr H. A. van Ysselsteijn, engineer to the city authorities. Messrs Nagel & Kaemp, of Hamburg, constructed the tip, while the electrical plant was the work of Messrs Siemens & Halske, of Berlin. The order for the third tip was passed to the contractors in 1897, but owing to some unforeseen delay it was not started to work until the beginning of 1901. This electric coal tip is illustrated in Fig. 353. The general dimensions are similar to those of the tip illustrated in Fig. 350, which was built by Sir W. G. Armstrong, Whitworth, & Co. Ltd. The framework was, however, made much stronger. The special novelty in the

* Illustrations reprinted from *Zeitschrift des Vereines deutscher Ingenieure.*

design is this, that the driving gears controlling the different motions have been placed in a separate engine-house erected close to the tip. Each movement has its own electromotor. Another feature special to this third Rotterdam tip is that the delivery shoot has been so constructed that it can be extended if coal has to be shipped into vessels of extra wide beam. It is thus equally suitable for loading coal into ocean-going steamers or into vessels for river and canal traffic. The waggons are drawn to the tip by an electric capstan, and are pushed upon the cradle. After discharging, they are returned

Fig. 345. Elevation of Cardiff Tip.

on another line of rails. The framework is, as has already been stated, similar to that of the Armstrong tips, but there are four uprights on each side of the cradle, the two centre ones of which also act as lateral guides for the up-and-down motion of the cradle. The four uprights on each side are stiffened by trussed girders, which are secured to a substantial foundation. The main uprights are girders of I section, and are composed of and riveted together with angle irons. The struts are made of channel section. The bases of the uprights are secured to cast-iron foot-plates, which in their turn are secured to

the foundation. The winding gears for the different movements of the tip, as already mentioned, are erected in a separate engine-room at the side of the tip. This arrangement has been adopted because it is held that the gears are thus under better control, and can be kept under the supervision of one man, whereas, if they were situated at the different points where their action was required, each individual winding gear would require its own compartment to protect it from the weather. It would also, under such conditions, be impossible for one man to manipulate all these gears. The slewing gear for the anti-breakage crane has been erected in the cabin of the operator, as may be seen in the illustration. The engine-house is fitted with an overhead crane so that repairs can readily and easily be undertaken. Although the winding gears have been erected in the engine-house, they are all under the complete control of the operator, who can stop or start any of them from his cabin at the top of the tip. The connection between the operator's cabin and the engine-house by means of levers would have been exceedingly complicated. All connections,

Fig. 346. Plan of Cardiff Tip.

therefore, are electrical, even the brakes on the winding machinery being thrown in and out of gear by small electric motors. The following six winding gears have been erected:

1. For lifting and lowering the cradle;
2. For tipping the cradle;
3. For raising or lowering the discharge shoot; and
4. For altering the incline of discharge shoot;
5. For lifting or lowering the anti-breakage skip;
6. For turning the anti-breakage crane.

The electric driving gears have been very carefully constructed, and the wiring has been insulated, so as to resist the damp climate of Rotterdam, and a continuous current of 500 volts. The lowering of the cranes is effected by means of electrical brakes.

1. *Winch for Lifting and Lowering the Cradle.*—The weight of the cradle, including the heaviest full coal truck, is 50 tons. This is raised at the rate of 1 foot per second. The action is illustrated by Fig. 355, which also shows the arrangement of the balance

Fig. 347. Hydraulic Tip at Barry Docks (Side View).

weights. The rope used is a steel wire rope, both ends of which wind on and off the grooves of the winding gear (Fig. 354), so that there is always the same tension on either end of the rope. The electric motor driving this winding gear is of 130 HP., and runs at 370 revolutions per minute. It is mounted on the same bed-plate as the winding gear. The drum has a diameter of 40 inches, which is necessary as the wire rope has a diameter of $1\frac{5}{8}$ inches. The gearing for reducing the speed from the motor to the winding drum consists of two countershafts and spur wheels. The gear wheels are of cast steel, except the pinion of the motor, which is of raw hide. The first of these countershafts is fitted with a brake at each end, which enables the operator to stop the load in free suspension, when the current is cut off. As soon as the cradle has reached the top of the frame, the current is automatically cut off by an arrangement on the second countershaft. During the lowering of the cradle the weights on the band brakes are lifted by a small electro-motor. The gear of the brake is also fitted with a dash-pot so as to ensure the brake action being smooth when thrown in or out of gear. The winding drum has, in addition to the grooves for the two rope ends, a third groove for a smaller rope. This is for the purpose of pulling the cradle down should repairs be needed, or for trial purposes, supposing the cradle should have to be lowered without a waggon on it. This rope is not usually on the drum, but is only put on in case of emergencies. This is necessary, as the cradle being practically balanced, will not, therefore, descend without an empty truck. All bearings of the winding gears and guide pulleys are of the roller type, friction being thereby reduced to a minimum.

Fig. 348. Hydraulic Tip at Barry Docks (End View).

2. *The Winch for Tipping the Cradle.*—This is illustrated in Fig. 356. The tipping process is thus effected:—The portion of the cradle which supports the coal waggon is hinged by two trunnions on the waterside, while two ropes at the back raise the movable part of the cradle for the purpose of tipping the contents of the truck. The diagram, Fig. 357, shows the connection of the ropes between the winch and the tip. With this arrangement the winch may run idle during the raising or lowering of the cradle.

There is also a third groove on the drum of this winch, for the purpose of keeping the tipping ropes taut. This winch is very similar to the preceding one. It has also two countershafts which gear it to an electro-motor of 60 HP., running at 530 revolutions per minute. The brake, similar to the previous one, is in this case also attached to one of the countershafts. The tipping portion of the cradle can be raised to an angle of 50 degrees. As soon as the incline has been reached the current is automatically cut off, and the weight of the empty truck and of the tipping portion of the cradle is sufficient to return the former to the level position, the speed being regulated by the

Fig. 349. Side View of Hydraulic Tip at Barry Docks.

brake. Just before the level position is reached the brake is pulled up tight. When lowering the cradle both the brakes of the hoisting and tipping gear are released. This is necessary as the winch has to run round idle again during the lowering of the cradle.

Fig. 350. End View of Hydraulic Tip at Barry Docks.

3 and 4. *Winch for Raising or Lowering the Discharge Shoot, and Winch for Altering the Incline of the Discharge Shoot.*—These are illustrated in Figs. 358 and 359. The apparatus is fitted with two independent sets of winding gear, which can be

alternately coupled to the electro-motor. Thus only one of the two operations can be performed at a time. The reversing of the coupling is done by hand. One of the winding gears serves to raise or lower the shoot, and the other to alter the incline. The rope connection between the winch and the tip is shown in Fig. 359, from which it will clearly be seen how the ropes operate the shoot. The dotted lines which indicate the

Fig. 351. Hydraulic Tip at Rotterdam.

ropes are clearly marked. The line composed of dashes and crosses controls the incline of the shoot, whilst the rope indicated by dashes and dots raises and lowers the shoot itself. The movement of this winch is designedly rather slow, as any alteration either to the height of the shoot or its incline is only very occasionally made.

The raising and lowering of the shoot is at the rate of 3 inches per second, whilst the movement of the end of the shoot to alter its incline is effected at the rate of 4

[*To face page* 328.

inches per second. The motor which drives this double winch is of 17 HP., and runs at 700 revolutions per minute, and as the difference in speed is so great between the winch and the motor, the transmission from one to the other is effected by means of worm and worm wheel. One of the two winches is fitted with a band brake, the weight of which is lifted or lowered by a small electro-motor, similar to all the other brakes on the winches. On either side of the frame of the tip, against two of the main supports, are fitted tooth racks into which the two pawls of the shoot are geared, so as to relieve the ropes of the tension until the shoot is to be raised or lowered again. No power is required to lower the shoot, as its own weight is always sufficient to turn the winch as soon as the brake has been released.

5. *Winch for Lifting or Lowering the Anti-breakage Crane.*—This is illustrated in Fig. 360. The crane itself is fitted to the frame of the tip in the usual manner. The winch will lift the weight on this crane at the rate of 2 feet per second. The

Fig. 352. First Hydraulic Tip at Rotterdam.

connection between the winch and anti-breakage crane by means of wire ropes may be seen from Fig. 361, which explains itself. The winch is driven by an 18 HP. electro-motor, which runs at a speed of 630 revolutions per minute. The brake is similar to those previously described.

6. *Winch for Turning the Anti-breakage Crane.*—This is illustrated in Fig. 362. The motor is connected to the turning gear by worm and worm wheel, and a pair of spur wheels. As mentioned before, this is the only part of the machinery for operating any portion of the coal tip which is not situated in the engine-house, but is fitted up in the operator's cabin.

The whole apparatus is so small and is so seldom used that this was undoubtedly the most suitable place for it. The motor is of 4 HP., making 1,000 revolutions.

The Cradle. It is of substantial construction, and is fitted with rollers which run against the guides of the framework of the tip. The sides are A-shaped, and there is a

connecting piece at the top end which joins the two together. At the waterside are two stands, accessible by steps, on which an attendant can take up his position. The

Fig. 354. Winch for Lifting and Lowering the Cradle.

tipping portion is built within the floor of the cradle, and is just wide enough for the two main girders to carry the rails upon which the truck stands. These two main

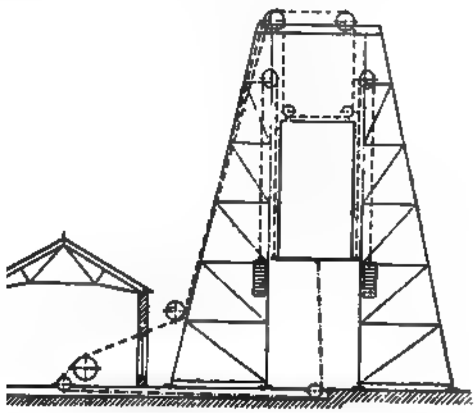

Fig. 355. Diagram showing Method of Raising and Lowering the Cradle.

girders are connected with each other by a framework of angle iron. A strong girder at the end extends across the two longitudinal girders, which run the full width

of the cradle. The ends of this girder are provided with attachments to which the tipping cables are fixed. The rails on the tipping portion of the cradle are level for about three-quarters of their length, but are slightly bent upwards for the last quarter,

Fig. 356. Winch for Tipping the Cradle.

thus bringing the truck to a standstill when it is pushed on the cradle. As the truck is pushed into position two automatic catches *aa* are pushed forward and prevent it from running backward. This is shown in illustration, Fig. 363, which gives the details of

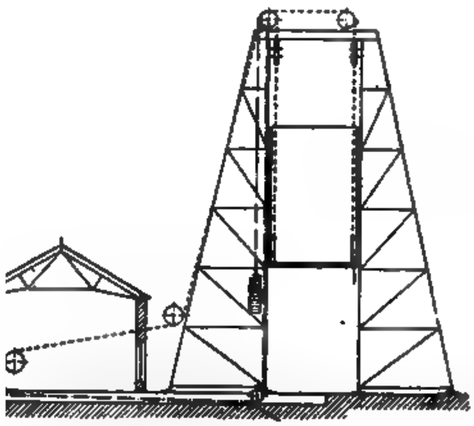

Fig. 357. Diagram illustrating Tipping of the Cradle.

the working parts of the cradle in plan and elevation. Coupled with the two catches *aa* are two further catches *bb* which secure the cradle in its position when empty. These are now withdrawn in order that the cradle may ascend. To make the truck still

more secure, the coupling chain at the end of the truck is attached to the cradle itself. This arrangement allows the truck to advance to its most forward position. As soon as

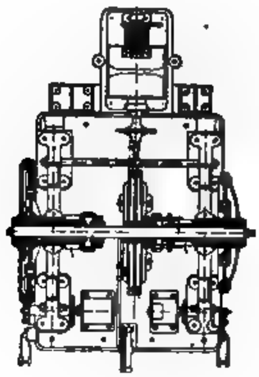

Fig. 358. Winch for Raising and Lowering the Discharge Shoot.

the tipping process begins the truck rolls forward into this extreme position. In doing so, it automatically secures its front axle by two substantial hooks, which are pressed

Fig. 359. Diagram showing Manipulation of Discharge Shoot.

upward. The action will be clearly understood from Fig. 364, which represents the hooks which fit the front axle of the truck. They are coupled together and are fitted

with a balance weight; the levers at the sides are pressed down by the front wheels of the truck, and cause the two hooks to rise. The method adopted in this tip is identical with that of the original Armstrong tip.

As has been said before, the cradle is balanced by counterweights which move up and down within the framework of the tip. The tipping portion itself is balanced in a

Fig. 360. Winch for the Anti-breakage Crane.

similar manner. Provision is also made for catching the cradle automatically should one of the ropes break accidentally.

The Discharge Shoot. This shoot extends from the tip to about the middle of an average sized ship. The upper or feeding end is 12 feet wide, but the shoot tapers at the tail end to 6 feet 6 inches. To this narrow end a lengthening piece is attached for

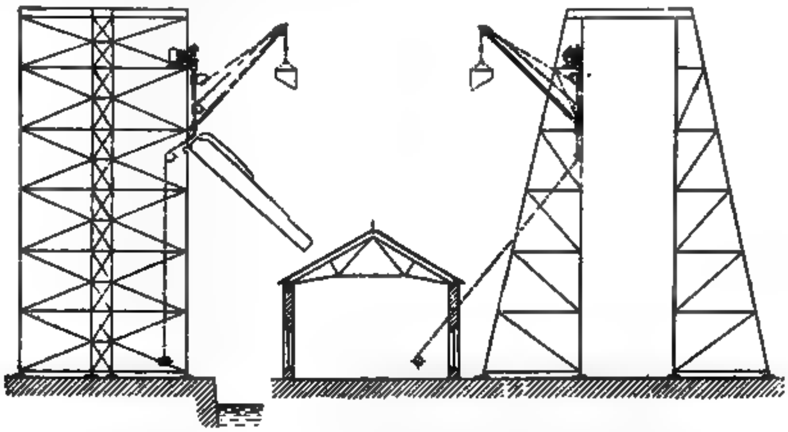

Fig. 361. Rope Connection between Winch and Crane.

extending the shoot so that it can reach to the middle of the largest steamers. This piece is attached to a central girder beneath the shoot, and as it is mounted on rollers it can be pushed backwards and forwards as required. This arrangement is operated by hand by means of a worm and worm wheel. The extension is principally used for loading offside bunkers.

Fig. 365 gives an illustration in plan and elevation as well as a cross section of the

shoot. The whole of the shoot is movable sideways round a steel pin Z, which is secured in position by cross girder X, held by cables and pawls as has already been described. Both the steel pin Z and cross girder X can be seen in the elevation of the shoot, Fig. 365.

Manipulation of the Tip.—As already mentioned, the winches, with the exception of one, are placed in the engine-house, but are all operated from the cabin at the top of the tip, from which point the attendant can have all movements under his observation. The electrical starting and stopping gears are arranged on two floors of the cabin, which is illustrated in Fig. 366, and shows a section through the cabin, a plan of the top and a plan of the bottom floor. On the upper floor will be found the starting gears for the lifting and tipping winches, and also for operating the discharge shoot, whilst on the lower floor is the starting gear for the anti-breakage crane, as well as the turning movement for the same. The stopping and starting gear for lifting and tipping are marked A and B. These are situated behind the manipulator, who faces the levers A^1 and B^1 from which the gear is operated. C is the starting gear for raising and lowering the discharge shoot. D is the trap door leading to the lower floor. E, on the lower floor, is the turning gear for the anti-breakage crane, whilst F is for raising and lowering the same, G being the space for the counterweight. The ordinary position of the attendant is between A^1 and B^1, and with his right hand he manipulates the raising and lowering of the cradle, whilst with his left hand he controls the tipping operation. With the backward movement of the lever the load is raised, whilst with the forward movement it is lowered. There is a safety appliance which prevents the tipping lever from moving during the raising and lowering of the cradle and *vice versâ*. The normal position of the levers is in the middle of the index, and as soon as one of the levers is moved in either direction from the middle position, the other lever is automatically locked until the former lever has again reached the central position. In addition to the operating levers, the cabin is fitted with the usual electrical instruments and cut-outs.

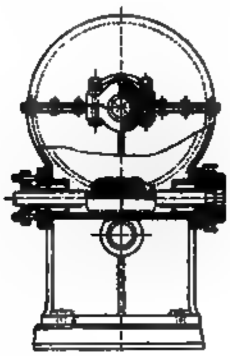

Fig. 362. Winch for Turning Anti-breakage Crane.

Coal Tip at Cardiff.—This was built by Sir W. G. Armstrong, Whitworth, & Co. Ltd., and is similar to the tips previously described. The capacity is 19 tons, whilst the lift of the cradle is 31 feet. This tip is very like one of those at Rotterdam, with the exception that the lifting machinery, which consists of a ram and cylinder with multiplying sheaves, is placed on the back of the framing. It is mounted on wheels, which allow it to be moved to and fro on the quay to reach the hatchways of vessels, there being on the quay a number of lines, opposite to any one of which the hoist can be placed. These lines radiate from turntables communicating with the full and empty railroads. These tips are most serviceable, as they enable two hoists to work into the same vessel, which, owing to the constantly varying position of the hatchways, two fixed hoists would very rarely be capable of doing. Fig. 367 illustrates this tip.

The tips built by the M'Myler Manufacturing Co., of Cleveland, Ohio, and of 34-35 Cock Lane, Snow Hill, London, E.C., are for the purpose of discharging cars which need neither be hopper-bottomed nor have hinged doors for unloading. The trucks are tipped by rolling them over laterally when they have reached the required level in the tip. Such a tip is illustrated in Fig. 368, and consists essentially of a

steel tower, similar to the Armstrong type of tip, which forms the guide for the cradle. The latter is provided with a rigid side toward the vessel to be loaded. Wire ropes are attached to the top of this side, passing upwards over the guide pulleys to a counterweight running in a groove at the rear of the tower. The hoist ropes are attached to a lower point on the same side of the platform, beneath which they are passed under guide pulleys, rising from thence to the top of the tower and back to the hoist winch. The platform is raised by a combined action of the ropes until the side meets an adjustable stop which checks the descent of the counterweight.

As the hoisting rope continues to pull it turns the cradle and brings the car in contact with the counterweight ropes, which hold it firmly against the rails whilst the

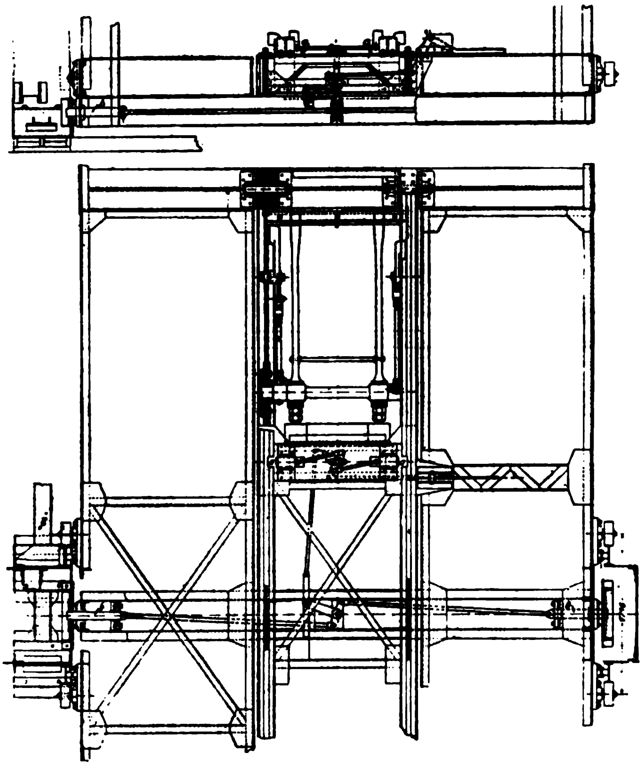

Fig. 363. Details of Working Parts of Cradle in Plan and Elevation.

load is emptied into an inclined spout which terminates in a telescopic tube through which the coal is lowered and trimmed. This extension reduces breakage and assists trimming in the ship's hold, as it can be moved about so as to reach from side to side of the ship.

The later tips on this principle, one of which is illustrated in Fig. 368A, are of sufficient size to handle loads of 75 tons, including coal and car.* The machine is so designed as to take the truck as it is delivered by gravity at the foot of the incline, haul it into the cradle, and empty the contents into the vessel, after which the car is led

* This tip has been fully described in a paper read by Mr J. D. Twinberrow before the Institution of Mechanical Engineers. See Proceedings Inst. M.E., 1900, page 574.

out of the cradle on to the track for empties. It is claimed that this machine has discharged as many as thirty cars and 1,000 tons of coal per hour.

"*Long's*" *Coal Tip.* This coal tip is the invention of Mr Timothy Long, of the Excelsior Iron-works, Cleveland, Ohio, U.S.A., and has been successfully put into operation at the Erie Docks, Cleveland.

The diagram, Fig. 369, illustrates the principle on which this tip works, although the one at the Cleveland Dock is at a higher level above the quay than the tip shown in this illustration.

This apparatus consists of a cylinder mounted at each end on rails on which it can revolve, and large enough to receive the railway truck. Within the cylinder is a continuation of the rails of the outer track by means of which the waggon enters. It is clamped in position, and the cylinder is then caused to revolve towards the shoot by means of cables and a winch. Through this partial revolution of the cylinder the waggon is tilted sufficiently to discharge the coal into a shoot or hopper, after which the cylinder is rolled back to the starting point, where the waggon again assumes its normal position

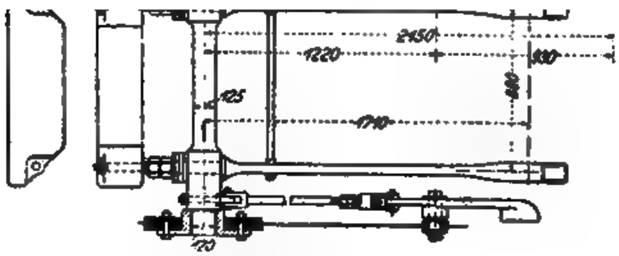

Fig. 364. Device for Fixing Railway Truck to Cradle.

and is pushed out by a full one. The cylinder is 40 feet in length and has an internal diameter of 11 feet, whilst the outer diameter is 16 feet. It consists of a strong framework, and has openings of sufficient size for the coal to pass through in the discharging position.

The capacity of this apparatus is stated to be three hundred cars of 7,500 tons of coal per day of twenty-four hours, and it is reported to have discharged three American bogie trucks into a vessel in three minutes.*

Coal Tips at the Goole Docks.—These are illustrated by two views, Figs. 370 and 371, and also by a sectional diagram, Fig. 372, although, strictly speaking, they do not come under this heading, as they do not deal with railway trucks, but tip barges which contain coal. These compartment barges (which are each 18 feet by 30 feet by 6 feet 6 inches deep) are brought down the Aire and Calder navigation. The boats pass along the canal in long strings, articulated together. On reaching the dock, the

* This tip was described in the *Scientific American*, 16th November 1895, page 312; also *Engineering*, 21st August 1896, page 211.

compartment barges are floated, one at a time, on to the submerged cradle of one of the coal hoists. The cradle is then lifted till the barge is clear of the water, when clips are made fast to the rear of the barge, securing it to the cradle. The lifting is then continued until the barge reaches a height of 35 feet, when it is turned over sideways and deposits the coal into a shoot by which it is conveyed to the hold of the vessel. The empty boat is then returned to a horizontal position, when the cradle is lowered and the empty boat floated off. Each barge holds from 25 to 35 tons of coal. The lifting of

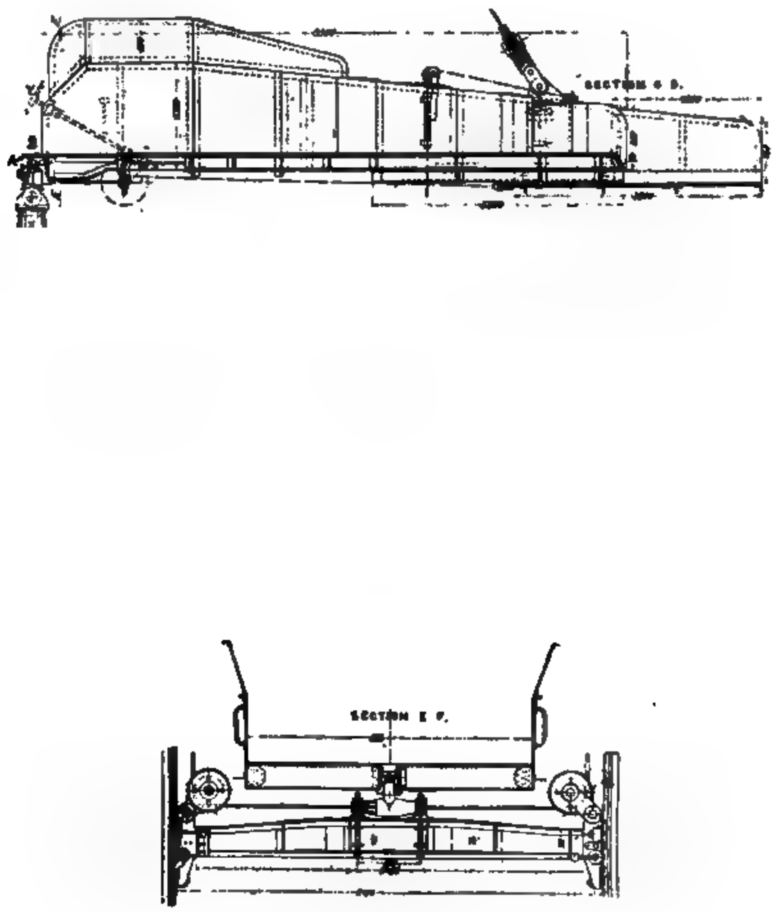

Fig. 365. Plan, Elevation, and Cross Section of Shoot.

the cradle is effected by direct-acting hydraulic cylinders placed vertically above the cradle, pistons with piston rods being connected to it.

The tipping movement in the first tip was effected by rotary hydraulic engines and chains, but in the later tips it was effected by cylinder and ram with multiplying sheaves and chains. These tips were built by Sir W. G. Armstrong, Whitworth, & Co. Ltd., the first being erected in the year 1863, the second in 1888, and the third in 1900.

Coal Tips at Penarth Docks.—One of the four movable tips at Penarth Docks is illustrated in Fig. 373. These four new movable tips are placed on the north side of

Penarth Dock Basin, and are built of steel, the main structure being of a total height of 96 feet. The tips are capable of being rapidly moved by means of hydraulic hauling engines. Every part of machinery of this hydraulic tip, the cradle, tipping, control of the shoots, and the movement and working of the anti-breakage cranes and boxes, is under the control of one man in the high cabin on the east side of the tip. All the machinery, which has to work under pressure, has been tested to carry a pressure of not less than 2,000 lbs. per square inch, and the working pressure is 750 lbs. per square inch. Each tip was constructed to fulfil the following requirements:—

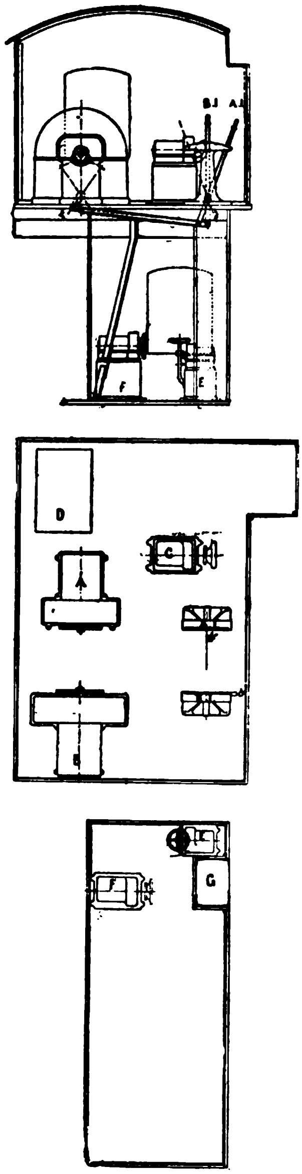

Fig. 366. Plan of Top and Bottom Floor, also Section through Cabin.

A loaded waggon having been placed upon the cradle, to lift it 45 feet above the quay, tip the contents of the waggon into the shoot, return the waggon to the quay level, and run it off the cradle within thirty seconds—and this can be accomplished.

The cradle is lifted from the ground level to any height up to 45 feet by means of four direct-acting hydraulic rams, two on either side of the cradle. These are as follows:—

Two small rams, one on each side, are in constant communication with the high-pressure mains, and act as counterbalances for the weight of the cradle itself. The large ram and cylinder on each side of the cradle are intended to deal with the weight of the waggon with load and of that portion of the cradle not balanced by the small rams. They are capable of lifting the cradle with a fully loaded 10-ton waggon upon it at the rate of 180 feet per minute.

The platform or cradle upon which the trucks are raised is shown in the front view in the illustration at its lowest position, whilst in the side view it is shown raised and tipped. The A-shaped sides of the cradle *a* are connected at the top by a girder *b*. This is again connected by the rods *cc* to a second girder which slides in the guides *dd*, which extend above the actual framework of the structure. The second girder is manipulated by the four hydraulic rams already mentioned.

The appliances for working the cradle are fitted with automatic stops b_1, so that, the height at which the tip shoot is required to work having once been fixed, the cradle when started ascends to the tipping point, where it is automatically stopped, so that the attendant has only to start the cradle for lifting, when he is free to handle the lever for tipping without further attention to the lifting of the cradle. Again, in lowering, as soon as the waggon has been tipped, the top man has only to open the release valve and the cradle descends, and is automatically stopped as it reaches the bottom.

Each tip is fitted with two anti-breakage cranes and Thomas's patent anti-breakage

boxes (see Fig. 374), and is capable of "boxing" (as it is termed) as rapidly as the coal can be delivered into the shoot. The small anti-breakage crane is also fitted with slewing gear for conveying coal screenings ashore.

The tip shoots *h* are 24 feet long, but can be lengthened up to 30 feet. In order

Fig. 367. Coal Tip at Cardiff.

that the coal may slide gently out of the shoots to avoid breakage, they can be rapidly adjusted by means of ropes *gg* and *f*.

The tips are quite large enough to hold a full 10-ton waggon of coal, the largest size used in the district. The shoots are fitted with double wings for assisting in the trimming of the coal and also in the boxing, and they are further made to radiate 5 feet

in either direction from the centre line of the tip, so as to assist in minimising the trimming.

In connection with each tip is a traversing turntable platform, and two turntables, one for the empty and the other for the full load. These platforms are also fitted with hydraulic capstans of a capacity of 2 tons pull, which can be moved to suit the position of the tips.

The whole of the hydraulic power required is brought to these tips by two mains, each 8 inches in diameter, so arranged that in the case of the failure of either one or the other, it is possible, by an arrangement of stop valves and branches connecting them together at intervals, to cut out any section of these pipes and so turn the water past the defective section. The return water is carried back by a 12-inch main to the hydraulic engines. Two large accumulators are fed from these mains; one at the eastern end of the tips, the other at the engine-house. The water is pumped by three pairs of compound "tandem" engines, collectively capable of delivering 1,440 gallons of water at a pressure of 750 lbs. per square inch per minute.

The sidings are so arranged in connection with these tips as to facilitate the mixing of coal and ensure rapid despatch. Provision is made by which all waggons are weighed on the way in and reweighed on the way out, the exact weight of the coal thus being ascertained, no matter what the tare of the waggons may be.

The sidings are so laid out that a full train can be put upon either. They will together hold a cargo for a steamer of 2,500 tons, and are so constructed, with a slight rising gradient to the centre and a falling gradient thence to the tip, that the men engaged at the tips manipulate the whole train load and work it down without the assistance of locomotives.

The capacity of these tips as regards despatch may be gathered from the following data :—

On 23rd May 1901, the S.S. "Gatesgarth" arrived in the dock at 8.10 on the morning tide, and immediately proceeded to the four-tip berth. After bunkering with one tip, she commenced to take in her cargo at 9.15 A.M., finished at 11.50 A.M., and sailed at the same tide, having taken on board a cargo of 2,333 tons in *two hours and thirty-five minutes*. On 26th July 1901, the S.S. "Bangarth" arrived in the dock at 11.45, and at 11.55 all four tips were at work, and she was charged with 2,154 tons of coal by 1.55, *i.e.*, two hours.

Thomas's anti-breakage box is the invention of Mr S. Thomas, Dock Superintendent at Penarth, and is illustrated in Fig. 374.

It has a capacity of 2¼ tons, the main object of its design being non-breakage of coal when working rapidly. It is in two sections, A and B, which hang vertically from the same bridle C, and are hinged together near the top of the box, being so arranged that when the box is empty the act of lifting it by a rope causes the box to close automatically, and it is closed while being loaded under the spout or shoot of the tip.

An auxiliary rope is attached by means of an eye-bolt and chain to the heavier half of the box, and passes up to the end of the jib of the crane which works the box, passing thence over a sheave on the outside of the jib, while the end is brought back down to the deck of the ship, where it is fastened at any desired length.

Upon the anti-breakage box being filled with coal, it is lowered into the hold through the descent of the main lifting rope of the box; the auxiliary rope tightens and the box opens as shown. As soon as the contents are discharged and the main rope

is lifted to bring the box back up to the shoot again, the auxiliary rope becomes slack and the box automatically closes, and is then ready for loading again, remaining closed until, by the lowering of the box, the auxiliary rope is again tightened.

The box is made of steel plates, angle irons, and "T" irons.

It may be added that this box is a great improvement upon the former system of anti-breakage boxes used in Cardiff.

The old style of box had a bolt for securing the door, but when working rapidly it frequently happened that this bolt did not drop into the right hole, consequently the door would open at the wrong moment and the coal was liable to be dropped too far and broken.

The Penarth installation was built to the design of Mr T. H. Riches, M.I.C.E., Chief Engineer to the Taff Vale Railway Co., by Messrs Fielding & Platt Ltd., of Gloucester, whilst the engines and hydraulic machinery were built by Messrs Tannett, Walker, & Co., of Leeds.

Fig. 368. M'Myler Coal Tip.

Coal Tip, by Pohlig, of Cologne.—Fig. 375 represents a coal tip built by J. Pohlig, of Cologne. Unlike those previously described, the railway truck in this tip is not taken up in a perpendicular direction, but at an angle of 45 degrees. The truck to be unloaded is pushed forward upon the cradle and put into position. The cradle is fitted with four wheels and ascends on the rails, to the top of the inclined structure, where these rails are so arranged that as soon as the cradle has reached the highest point the front wheels are lowered sufficiently to put the cradle, and with it the truck, in a position at which the coal will leave the truck. The engine and winding gear necessary for this installation are placed at any suitable point in close proximity to the tip itself. The cradle is so balanced that the winding gear has only to perform the actual work of elevating the coal. There is also a safety brake which will not allow of the cradle descending at an excessive speed, even if the cable of the winding gear should snap. The truck discharges its load into a hopper, from which

Fig. 369. Long Coal Tip.

it is fed by means of a spout into barges. If the hopper is kept full there will be but little breakage in the delivery of the coal, and if carefully manipulated by means of the hand wheel the coal will leave the shoot at the same rate at which it enters the hopper.

With these tips the truck must always be elevated to the same level. They are therefore only suitable for non-tidal rivers and for vessels of uniform dimensions.

Fig. 370. Side View of Coal Tips at Goole Docks.

The Brown Electric Coal Tip.—Fig. 376 represents this tip, which was erected by the Brown Hoisting Machinery Co. for the Carrie furnaces of the Carnegie Steel Co. By means of this machine the 50-ton ore waggons are picked up and emptied sideways into a bin holding several hundred tons. From this bin the ore is drawn out through suitable openings into buckets holding 10 tons each. These buckets are placed on electric travelling cars which each hold four buckets.

The loaded truck is pushed on the cradle in its lowest position by means of a car-pushing device. The cradle will take any sized truck from the largest to the smallest. The truck is secured in position by hydraulic clamps on top and sides, the engine is started, and slowly turns the cradle over until the car is in a discharging position. During this process of overturning, the material flows into hoppered compartments

Fig. 371. Front View of Tip at Goole Docks.

attached to the cradle, from which it passes through transfer tubes, these hoppers being each of them connected with the transfer tube. These compartments have doors which are automatically released on touching the lower end of the transfer tubes. Each car is displaced by the next loaded car coming along, and is run by gravity to the empty track, the process already described being then repeated. Thirty cars per hour may be handled with such a tip.

Hydraulic Crane Tip at Middlesbrough.—Another type of coal-loading apparatus is illustrated in Fig. 377, and represents the movable hydraulic crane tip at Middlesbrough. It is for loading coal direct from the docks into ships. The crane consists

Fig. 372. Sectional Diagram of Tip at Goole Dock.

of a heavy pillar revolving in a built pedestal, which has an archway large enough to pass a locomotive and box waggons. The lower part of the pillar is carried in a footstep attached to the bottom of the pedestal above the archway, while the upper

›p of the pedestal. The pillar carries jibs which can be varied within wide limits by inclined position at the back of the pillar, of the jib by girders. The turning of the lers placed at the back of the pillar, along-

Гip at Penarth Dock.

chain which fits into a cupped drum round nanism is placed within the cheeks of the with rams and multiplying sheaves. There the turning cylinders on the back of the ‹ which the rear end of the waggon is tipped

up. Attached to the lifting and tipping chains is a cradle for receiving coal trucks of either end or bottom door pattern. This cradle fits into a seat which can be placed on the rails at any point without in any way cutting up the quay. The moving of the crane is effected by a hydraulic engine placed in the pedestal connected to the travelling wheels by shafts and gearing. This hydraulic crane has a lifting power of 15 to 30 tons, the height of lift being 66 feet. It was built by Sir W. G. Armstrong, Whitworth, & Co. Ltd., and is one of the latest developments of this kind of tip. Similar cranes were erected at Avonmouth Docks and elsewhere, but with the earlier tips it was necessary to have a pit between the rails into which the cradle for the reception of the railway trucks fitted. The crane at the Avonmouth Dock was built for handling coal from the local coalfields near Bristol, from the Radstock district; for South Wales coal which comes *via* Severn Tunnel, as well as for coal from the Forest of Dean and the Midlands. This crane lifts the truck on the cradle, which is then swung over the hatchway, the coal being tipped into the vessel. A similar tip is also used at Fleetwood.

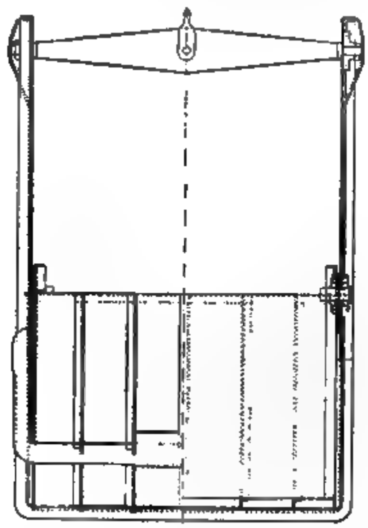

Fig. 374. Thomas's Anti-breakage Box.

The crane is moved on rails laid alongside the quay, and the cradle is so constructed that the trucks can be picked up from and deposited upon the rails at any point where the crane may be. The truck rests on the cradle which fits between the rails, so that the waggon may be run off at the opposite end to the point at which the loaded trucks enter. Thus no sidings or turntables are required, and the train of waggons can be lifted and tipped in succession while the empty trucks are taken away on the same line of rails and in the same direction. The cradle is worked by the outside pair of chains, which are manipulated by a different cylinder and ram from the one actuating the tipping.

The tipping is arranged for the centre chain, which separates above the swivel, its two strands passing, at this point, over guide pulleys on the lifting beam above the cradle. Both lifting and tipping chains are attached to the cradle, the tipping chain being attached to the rear end of the vessel. The lifting and tipping motions are each controlled by hydraulic power, and are operated by a man standing in a cabin in the front of the crane pillar.

A tip similar to the above is installed at Bremen, Germany.* With this tip the coal truck to be discharged is run on a platform which forms part of the track passing along the quay-side. The crane then picks up this platform with the truck upon it, and swings it round until the end of the car is over a large hopper which is suspended from the upper arm of the same crane, over the ship to be loaded.

The truck arrives here in a horizontal position on its platform, as it has been elevated simultaneously by two sets of hydraulic hoists, one of which is connected to the front and one to the rear chain supporting the platform. By raising the rear chains the platform is then tilted until the load has been discharged in this suspended hopper. The manipulator's cabin is in front of the crane, and in full view of the whole of the operations. The crane has been built for loads of 26 tons, the extension of the jib end

Fig. 375. Coal Tip built by Pohlig.

being 26 feet, whilst the load can be raised to a height of 32 feet. The special jib which supports the hopper has a radius of 36 feet and a lift of 45 feet.

This installation was built by C. Hoppe, of Berlin. Similar cranes, but of larger proportions, are being built in America.

The Cowans Sheldon Crane Tip † is again of similar construction; it is built by Cowans, Sheldon, & Co. Ltd., of Carlisle, and is intended for loads of 25 tons which are lifted by a single chain. The lifting and turning are effected by hydraulic power, the hydraulic piston being placed horizontally under ground, and being manipulated from a cabin erected by the side of the jib crane.

* This tip has been described in a paper read by Mr J. D. Twinberrow on the "Capacity of Railway Waggons as affecting Cost of Transport." See Proc. Inst. Mech. Engineers.

† This tip has been described in *Engineering*, 29th April 1898, page 531.

The radius is 34 feet 6 inches, and the height from quay level to the centre of the jib top pulley is 50 feet.

Lewis and Hunter's Coal Tip at Cardiff Docks.—This apparatus consists of a tip discharging its load on a level with the line. Self-discharging railway trucks can also be

Fig. 376. Brown Coal Tip.

used, in which case the tip is not necessary. The tips, which are, however, mostly used in this system, discharge the coal into a skip which holds the contents of the waggon, and the coal is elevated in this skip by a hydraulic jib crane, swung round over the hatch, lowered into the hold of the vessel, and there emptied. The crane is capable of

travelling with its load along the quay wall, and is thus able to reach hatches at varying distances from the tip.

With 10-ton waggons 293 tons of coal have been tipped on board a steamer with one crane in an hour. One crane is therefore capable of working at the rate of 30 skip-loads per hour. The actual working rate in practice is, however, lower than this, and the following record published by the patentees gives the time taken and the quantity of coal loaded with two cranes:—

Name of Steamer.	Quantity.	Time.	Tipping Operations per Hour with One Crane.
	Tons.	Hours.	Tips per Hour.
Lancashire - -	5,817	20	14·5
Asama - -	5,833	30	9·7
Knight Companion - -	6,411	34	9·4
Runic - -	6,218	28	11·0
Rhympha - -	3,303	16	10·3
Isle of Anglesea -	2,033	13	7·8
Inchlonga - -	4,133	27	7·7
Orsino - -	2,781	12	11·3
Nedgid - -	3,910	13	15·0
Wingates -	2,866	11	13·0
			Average, 11·0

A case may be mentioned of a steamer which went into berth at 5 P.M., and by 5.30 next morning had taken in 1,609 tons of coal, an average, after deducting stoppages, of 189 tons per hour, so that in this case 1,609 tons were shipped by one crane in 8½ hours.

The nett loading time, after deducting delays incurred in waiting for coal, of the S.S. "Samoa," was 28 hours, in which time she took in 7,484 tons of cargo and 1,750 tons of bunkers, or an average of 330 tons per hour.

The S.S. "Iran," which was loaded by four cranes, took on board 9,213 tons of coal in a nett loading time of 26½ hours, or on an average 347 tons per hour.

This system is the invention of Sir William T. Lewis (general manager) and Mr Charles Hunter (engineer) of the Bute Docks, Cardiff, and has been adopted by the Cardiff Railway at their Roath Dock, Cardiff.

Tips similar to the foregoing, in which the railway truck is emptied into ordinary and mechanical skips holding the full contents of the truck, which are then emptied into the ship's hold, have been designed by G. T. Wart, colliery manager of the East India Railway; also by the Wellman Seaver Morgan Engineering Co. Ltd., Cleveland, Ohio. Besides these may be mentioned the Butler and Fielding system.*

Other noteworthy devices are intermittent appliances in which the contents of the truck are emptied either on or below the level of the rails into a hopper from which they are transferred by a smaller skip to the ship, and then lowered into the hold.

Good examples of this type of tip are those erected for the East India Railway by Sir W. G. Armstrong, Whitworth, & Co. Ltd. in 1893; the Rapier coaling crane; also the one erected at the Kidderpore Dock, Calcutta, by Sir W. G. Armstrong, Whitworth, & Co. Ltd.

* This system was fully described in the *Engineer* of 2nd June 1893.

In this instance each skip holds one half of a waggon load, or about 5 tons. The Beckett system, which is the invention of Mr W. T. C. Beckett, deputy agent and chief engineer, Bengal-Nagpur Railway, also belongs to this type of coal tip.

Fig. 377. Hydraulic Crane Tip at Middlesbrough.

CHAPTER XXII.

COLLIERY TIPPLERS.

The coal tips described in the foregoing pages are mostly intended for the purpose of manipulating standard gauge railway trucks, but there is no reason why similar appliances should not be built on almost identical lines for the purpose of emptying colliery tubs. Appliances for this purpose are, probably on account of their smaller size, of very different construction. They are generally known as tipplers, and are built in a variety of forms, in most cases extremely simple, and too well known to require detailed descriptions, those delivering backward always being preferable, as they cause less breakage than those delivering in a forward direction.

A few types of more recent construction are worthy of notice, and are here fully described.

It will be seen that these coal tipplers are mostly of the type which discharge below the level of the rails.

Fig. 378. Perspective View of Rigg's Tipping Machines.

Of the many improvements introduced for the purpose of minimising breakage, the machinery for tipping coal with the least possible damage stands perhaps first, as the value of coal is in almost all cases dependent upon the size of the pieces received by the consumer. From its arrival in the tub or tram at the pit's mouth each transfer from one receptacle to another has the effect of more or less diminishing its value. Though the more friable kinds of coal sustain damage by abrasion, more or less inseparable from transit in railway trucks, the most serious damage is generally incurred in tipping at the pit and in loading on shipboard. At collieries many different devices have from time to time been adopted with a view to preventing breakage, but these devices necessarily vary with the character of the coal in different districts. Thus, in Monmouthshire and South Wales the iron and steel trams are provided with hinged end doors or bars, which are removed on the fore-wheels falling into recesses at the head of the screen; or else the necessary angle of delivery, about 35 degrees, may be obtained by a tram being placed on an oscillating platform so arranged as to allow of its tipping to the required angle of clearance.

The so-called "box tubs"—that is, tubs having no doors—are also variously tipped in balanced and unbalanced frames either backwards, forwards, or sideways on to the

screen, sometimes under the control of a brake. In cases where the coal is not heaped above the top of the tub, a horizontal door is sometimes shut down upon it, and not released until the tub is inverted over the screen. All these methods are bound to cause a great percentage of breakage, and are therefore superseded in modern collieries by more scientific tipplers.

The Rigg Colliery Tippler.—A tippler which greatly reduces breakage is that designed by Mr James Rigg, of London.

The rotating bonnet which receives the tub is so balanced that the position of the centre of gravity depends upon the tub being loaded or discharged, and therefore causes it, under control of the brake, either to tip forward and empty itself, or to return unloaded. Within this bonnet is a horizontal hinged door, which has an important function to fulfil, as at whatever speed the machine may be working, this door will act as a regulator to the flow of coal, while gradually but steadily yielding to its pressure. In reality it combines with the shoot in spreading the coal over the screen or sieve, into which it is generally discharged.

Fig. 379. Screen Receiving Tub-load of Coal.

Fig. 378 gives a perspective view of these tipping machines working in connection with Rigg's curved balanced screens.

The diagram, Fig. 379, shows the screen in its normal position receiving a tub-load of coal, which passes down the incline and is gradually brought to rest under the lower screen bars, as shown in Fig. 380.

The brake is again released, and the screen returns to its normal position to receive another load, these operations being effected during the period necessary for changing the tubs in the tip above.

The slack or small coal which has been eliminated by the screen is received in the fixed hopper shown and thus passed into its own trucks.

Fig. 380. Screen in Stationary Position.

The "Fowler" Patent Gravity Tippler.—During the past few years the "Fowler" patent tippler, which also works by gravity, has come into considerable use in this country. It is of course much smaller than the three-tub tippler, and does not require any more height at the rail level than an ordinary power-driven tippler.

It was originally built of cast iron, but Messrs Heenan & Froude Ltd., who have taken up the manufacture, are building it of mild steel for the handling of large material. It is claimed that thereby the diameter is decreased, the cost of construction reduced, and the durability of the tippler much increased. It has a tipping capacity of eight tubs per minute.

The tippler is also fitted with an ingenious arrangement which holds the tub in position in the cage by a system of automatic claws that grip the spindles of the tubs. During the tipping process this arrangement is perfectly automatic, and consists of four claws in each of the two compartments. When the tippler is emptied for the ingress

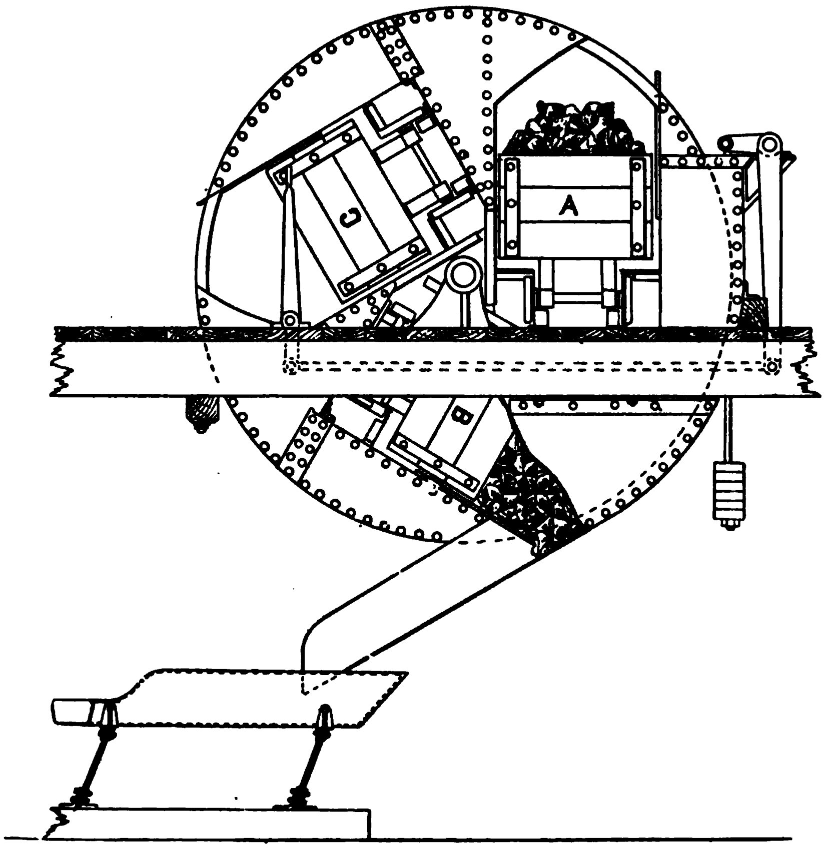

Fig. 381. "Sams" Coal Tippler.

of a tub, these claws are backed clear out of the way, but as soon as the tippler commences to revolve, the claws immediately move out and tightly grip the tub till it again reaches a horizontal position, when they automatically release their hold.

"Sams" Coal Tippler.—The "Sams" coal tippler is a modification of the tip previously described, and combines the simultaneous handling of three tubs, so that the speed at which each tub is unloaded does not exceed the speed at which ordinary tubs are cleared.

It is built by Messrs Heenan & Froude Ltd., and has several excellent features.

It has hitherto only been used for emptying colliery tubs, but there is no apparent reason why it should not be built on a scale large enough to take ordinary gauge railway trucks.

This appliance is illustrated in Fig. 381, from which it will be seen that the tippler contains three compartments for three tubs which run in one cage, the rotation being caused by the weight of the loaded tub A. The action of the machine then is as follows:—

The loaded tub from the weighing machine is run into the tippler with sufficient velocity to eject the empty tub at the other end by the impact. When at rest the tippler is held in position by two powerful brakes which pass round the two end rings. These brakes are actuated by a lever arrangement under the control of the attendant.

On the movement of a lever the brakes are released, and the tippler rotates one-third of a revolution, and is again brought to rest in that position. This brings tub C into the position just vacated by tub A. C is then removed and replaced by a new and full tub as before. The tub A takes up the position shown at B, in which position the side of the tippler stands at an angle of 30 degrees, an oblique plate at the side

Fig. 382. Diagrams showing Action of Rigg's Power-driven Colliery Tippler.

of the tub forming a temporary hopper into which the coal is discharged, the coal being held in this position until the succeeding tub is tipped, when the tub previously emptied takes the position at C. This is of great importance, as the stop at point B gives the tub time to gently empty itself. This tippler can be made with a cage which will automatically arrest itself in three different positions, but it is generally found more convenient to allow it to be manipulated by an attendant.

The same arrangement for automatically holding the tubs in position while tipping is used with this appliance as has been described in the case of the "Fowler" tippler. That is to say, four claws are made to automatically seize the spindles of the tub until it reaches a horizontal position, when they automatically release themselves.

These tipplers are made in sizes running from 6 to 10 feet in diameter. They consist of two mild steel rings built up of channel steel and joined to the centre boss by channel steel arms of the same section, which are held together by gusset plates, as shown in the illustration. The end rings are joined together by side plates of $\frac{1}{2}$-inch metal and also by angle irons which form the rails for the tub. The whole apparatus is suspended on a mild steel shaft of 4 inches diameter which revolves in two substantial cast-iron bearings.

Rigg's Power-driven Colliery Tippler.—The tip on this system describes a rotary oscillation only, and not a complete revolution, as is generally the case.

This power-driven tippler combines all the advantages of the gravity tippler, with the increased speed necessary to enable a large output to be fed on to the picking belt. The speed of the oscillation is slow only during about 10 degrees, while the coal passes from the tippler to the belt or to the intermediate jigging screen.

The diagrams, Fig. 382, show the means by which the varying forward and return oscillations are obtained. Fig. 383 is a side elevation of the actual machine.

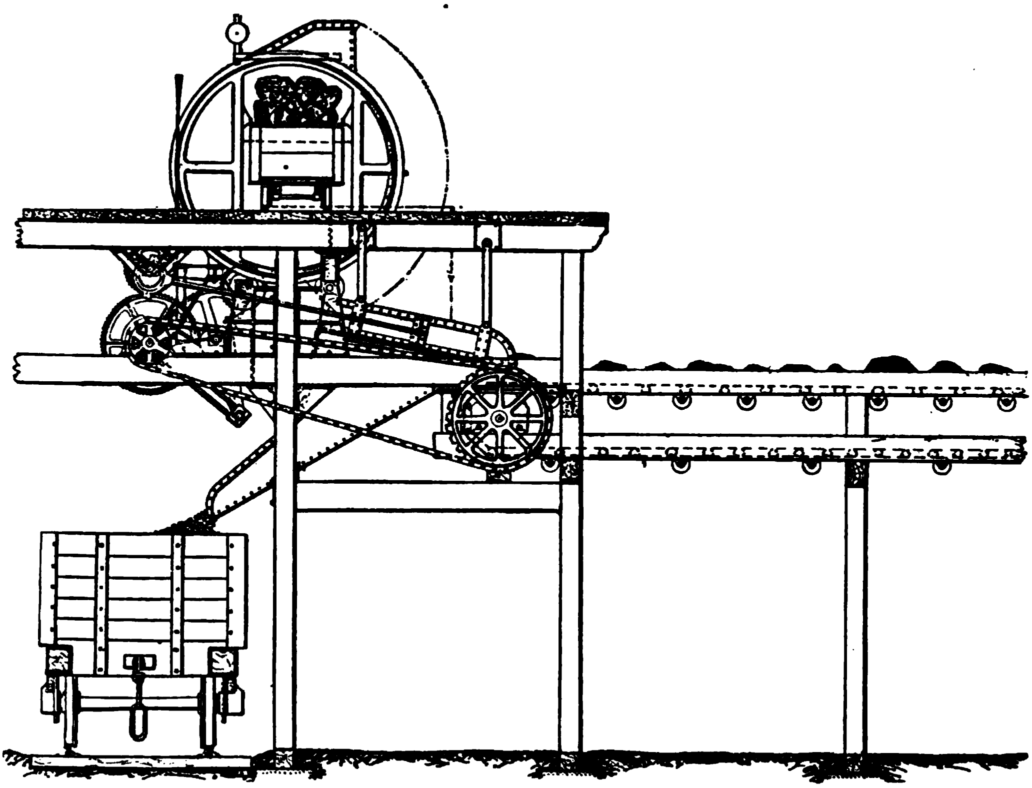

Fig. 383. General View of Rigg's Power-driven Colliery Tippler.

The shaft G, Fig. 382, is driven at a uniform speed, the pin g on the crank H^1 being connected to an arm, and the toothed segment E^1 communicating motion to the pinion B^3 and also to the wheel B^2, which is geared into the rack A^2 attached to the tippler A. One revolution of the shaft G causes the double oscillation of the tippler through the arc indicated by the dotted lines. It is important to observe that the three equal arcs, $g\ g^1$, $g^1\ g^2$, $g^2\ g^3$, of this portion of the path of the travelling crank pin correspond, as stated, with the varying velocity of travel of the tippler, as indicated by the letters $a\ a^1$, $a^1\ a^2$, and $a^2\ a^3$, and this variation, as well as the return of the empty tub, is well adapted to secure an extremely rapid motion when coal is not leaving the tippler, and a slow one prior to, during, and for a brief period after its delivery.

CHAPTER XXIII.

MISCELLANEOUS LOADING AND UNLOADING DEVICES.

The "Kindl Machine" for Loading Ore and Coal.*—The objection has been raised that in the typical American plants for unloading vessels of coal and ore the dead moving load is great in comparison to the actual material carried.

Great interest, therefore, attaches to the apparatus of Mr F. H. Kindl, an engineer who has been for some time connected with the Carnegie Steel Co. In his machine the dead load requiring to be moved is the bucket carrying the ore. This bucket weighs about 2 tons, while the amount of ore it carries when full is estimated at 5 tons. The digging arm being at an angle, has a working radius of 16 feet. Very little movement of the machinery is required (excepting the rotary motion of the digger arm) to clear out the hatch of the vessel. It is claimed that by means of this apparatus a load equal to 4,000 tons can be lifted from the hold of a boat in ten hours, while the labour charge for unloading 1 ton of ore will not exceed ⅛d. from the vessel to the truck. This machine is so designed that it can be operated in conjunction with the present bridge equipment of the Conneaut Docks, the Carnegie Steel Co. having obtained the right to use this appliance at their docks, Conneaut, O., as well as at their coaling stations in the Pittsburg district, for unloading coal from barges. The machine is mounted on a structure which is movable along the dock, so that all parts of the hold can be reached by the discharging apparatus with no danger either to the latter or the vessel during the process of unloading.

A general elevation of the machine is given in Fig. 384, while Fig. 385 shows the upper portion of the tilting frame, trolley, and hopper. Fig. 386 is a vertical section through the unloader with the bucket in its place. Fig. 387 is a side elevation of the driving mechanism. The travelling structure A is mounted on wheels and runs on tracks sufficiently far apart to allow room for three standard gauge sidings for the trucks into which the ore is discharged. The structure A supports the entire apparatus, and is propelled by means of an electro-motor connected by suitable gearing, as shown in Fig. 384, while by means of the reversing lever the machine may be moved in either direction along the tracks so as to bring it to any desired point for operating upon the material. On the central portion of the framework and extending lengthwise are two rails carried on hangers, between which is mounted a hopper C, supported on wheels resting upon these rails. This hopper C is moved along the rails by an electro-motor geared to one of the axles. Above this hopper track is pivoted a swinging bridge D, mounted on trunnions. The bridge is formed of girders spaced and secured together by bracing, and having rails fixed to the upper surface. These are provided with stops at each end. A trolley E, moving on these rails, is provided with bracket arms having shoes which engage with the under side of the bridge and preserve the stability of the trolley as the bridge and leg are tilted. This framework has side

* See *Iron Trade Review*, Cleveland, Ohio.

bearings and a turntable, and on the under side of the latter is an internal gear with pinions attached to shafts extending upwards to the mechanism at the top of the unloader, and by this means a rotary motion can be imparted. Two semicircular wheels F project downward from the supporting frame of the turntable. These are driven

Fig. 384. General Arrangement of Kindl Unloader.

by worms, the teeth on one side of the machine being right-handed and the teeth on the other side being left-handed.

The worm shafts are connected by bevel gears to a horizontal shaft driven by means of a friction clutch. A spring normally holds the friction clutch in an open position, and a lever is moved to close the clutch against the action of the spring by means of a cord extending down to the operator's cabin near the lower end of the unloader. This cage is seen within the hatchway of the vessel shown in Fig. 384. Wire cables G

carry the load comprising the bridge, trolley, and unloader. These cables are connected to links attached to the outer ends of the trunnions of the frame supporting the turntable, and thence the cables extend over two pairs of sheaves at the top corners of the vertical framework. Each of the cables consist of four wire ropes, and each rope has its own groove in the sheave. The cables pass down at the back of the framework and are secured at their lower ends to a counterweight. Above this main counterweight are placed similar weights having at their ends successively deeper recesses from the top downwards. When the bridge is in a horizontal position the entire system of counterweights becomes effective, but as it swings upward from the horizontal to the position indicated by the dotted lines in Fig. 384, these counterweights will be successively arrested by and supported on a corresponding series of brackets. The counterweights are controlled by guides to prevent their swaying during the swinging of the bridge. The weight of the combined counterweights is more than sufficient to counterbalance the bridge and its load. The machine is then drawn downwards to a working position by means of cables H, extending from the side members of the bridge to winding drums driven by an electric motor mounted on the frame. The cables H extend upwards through stirrups on the bridge and are secured to caps which rest upon sets of volute springs. The downward pull of the cables is thus exerted on a yielding resistance, and when the bucket is digging the material from the vessel the motion of the latter, exerting a lift on the unloader, will swing the bridge upward and so compress the springs, the yielding connection thus preventing injury to the bottom of the boat or the machinery, which might result from a rigid construction. The apparatus is made in hollow form and secured to the turntable through which it extends. The extreme lower portion of the elevator projects at an angle as shown in Fig. 384, and guides are provided which extend from end to end of the interior.

Fig. 385. Portion of Kindl Unloader.

The bucket I is equipped with trunnions attached to the hangers and pivoted links having a cross-bar, to which is secured the lifting cable J. The bucket moves within the hollow apparatus, and is provided with rollers to act as guides in the up-and-down movement. The rollers K, engaging guides at the hoppered portion there, tilt the bucket into the position shown in Fig. 385, and thus deposit the material into the hopper W.

The bucket enters a holder L, Figs. 384 and 386, at the lower end of its travel, and

the trunnions rest in V's at the sides, the bottom of the bucket resting against fixed supports. The bucket-holder consists of a hollow case open at both ends, with side trunnions projecting through stationary bearings at the bottom of the unloader, the trunnions having sprocket wheels O, round which pass chains M. The chains M at the bend pass over guide wheels, and at the upper end of the leg travel over sprocket wheels N, operated by driving mechanism. The bucket-holder and the bucket are rotated by these chains and sprockets to scrape up a load of ore, and to assist in this action the end of the holder is curved, as shown at P, and provided with a movable knife.

An electro-motor at the top of the apparatus turns the bucket-holder, rotates the turntable, lifts the load, and, after emptying the bucket, returns it to the position within the hatchway, the elevator being rotated by means of gearing which is thrown into action by a clutch manipulated from the operator's cabin.

A loose worm Q (see Fig. 387) is employed to drive the mechanism rotating the bucket-holder. The worm Q is in pitch with a wheel R, which, by a set of wheels, drives the sprocket wheels. The hub of the wheel S is enlarged and provided with a cam groove having an offset at T. A roller fits the groove and operates an arm having a forked connection with a clutch operating the loose worm Q. The lever is drawn down against the action of the spring by a cord U, leading to the operator's cabin.

In order to raise and empty the bucket and return it to the hatchway, a loosely mounted winding drum V (see Fig. 385) is driven by worm gearing. The winding drum is made with disc and band brake, one end of the brake band having a lever connection which is normally drawn down by a spring. A cord is used to release a latch for the purpose of loosening the band and throwing the brake out of action. A tappet or tripper is clamped to the hoisting cable in such a position that as the bucket reaches the upper end of its travel the tappet strikes an arm and detaches the drum clutch, at the same time applying the band brake by the mechanism already described. The bucket now being emptied, the friction on the disc will hold the bucket until the brake action is partially relieved by the operator, when its weight will cause it to descend, the speed being regulated by the help of a counterbalance, and the operator can thus regulate or stop the movement of the bucket by the cord leading from the counterweighted lever over a suitable pulley and thence to the cage. The controller for the electro-motor at the top of the apparatus is situated in the operator's cabin, so that he has under full control the movements of the unloader, bucket and bucket-holder, as well as the motion of the trolley.

Fig. 386. Working Arm of Kindl Unloader.

The hopper is of annular form, and is provided with an inclined bottom. In order to prevent the ore from dropping freely the entire depth of the hopper on its lowest side, an inclined portion is attached which projects inwardly, and at the inner end is attached to the cover of the lower portion of the hopper.

At the outlet door of the hopper an ore trolley is provided having double wheels with a central flange arranged to run on two sets of rails. The rails of the outer track extend from the pivoted point of the bridge inwardly to the point marked X (see Fig. 384), whilst the rails of the inner track are placed between the outer rails and pivoted at their outer ends to links attached to the trolley, the inner portion of the rails resting

upon a set of transverse rollers. When the machine is in the position shown in Fig. 384 the inner ends extend to the point marked Y, and as the trolley is moved backwards and forwards on the bridge the inner rails move over the supporting rollers and constitute movable extensions of the main track. A small electric motor is mounted on the two sets of rails. After it has received its load from the hopper it is moved back on the inner rails until the outer half of the wheels strike the outer rails, after which it is removed to a position over the movable hopper above the truck on the dock. The ore is then shot into the hopper and thence to the trucks on the track beneath. The rails of the movable track are secured by stringers which are rigidly braced together.

In operating this unloader the electro-motor propels the machine along the dock to the requisite position alongside the vessel, with the bridge in the position shown in dotted lines in Fig. 384. The hauling cables H are then wound on their drum, and the bridge swings down into a horizontal position, the apparatus at the same time

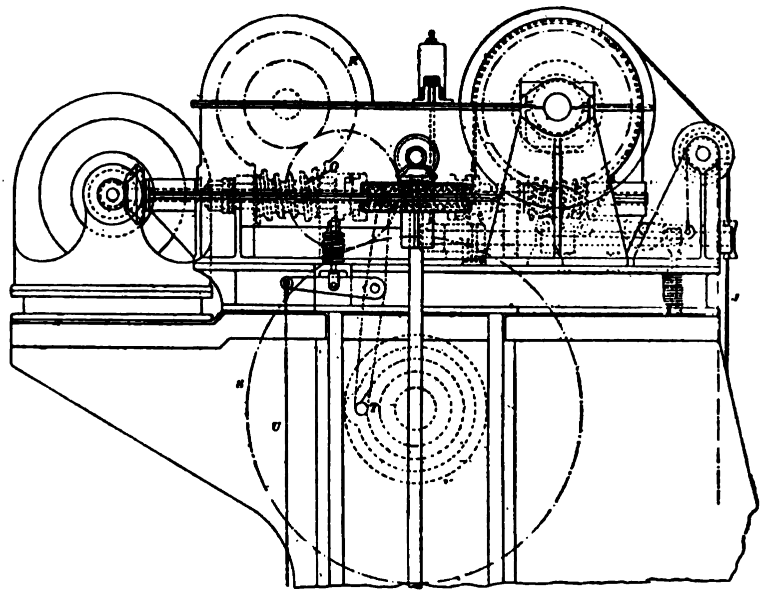

Fig. 387. Driving Gear of Kindl Unloader.

entering the hatch of the vessel, and the parts of the machine assuming the position seen in full lines in Fig. 384, while the trolley moves along the bridge to bring the unloader into the correct position. The operator from his station in the cabin at the lower part of the apparatus brings the working arm into position by starting the motor for driving the turntable or swinging the tilting frame or both, and moving the trolley on the track. He then starts the rotation of the bucket-holder by pulling up a clutch cord and releasing the cord as the holder moves. The bucket-holder makes one rotation, and as it returns to its original position, with the load scooped into the bucket, the automatic release stops it at this point. The operator then pulls the cord for the drum clutch, and the hoisting mechanism draws the bucket upwards. As it nears the end of its travel, the top trunnions engage with guides, and the bucket is tilted until it strikes the spring buffers. When the bucket attains the inverted position, the tappet on the hoisting cable strikes the lower lever, throwing off the hoisting drum clutch and applying

the band brake. The operator then releases the brake, and the bucket falls down the unloader and into the holder under control of the brake. When the desired amount has been taken from one hatch, the cables H are unwound a sufficient distance to allow the inner part of the elevator and the bucket-holder to rise above the deck of the vessel, the counterweights acting to swing the bridge upward when the cables are released. The machine is then moved to the next hatchway, the bridge again hauled into position, and the unloading continued.

The "Wall" System of Coal Loading.*—Mr Samuel M. Robins, Superintendent of the New Vancouver Coal Co., Nanaimo, B.C., having to face the difficulties incidental to an antiquated system of end-on wharves (relics of the Hudson Bay Co., the original owners of the mines), from which he had to feed a fleet of steam colliers of 4,000 to 6,000 tons burden, engaged in carrying steam and household coal to San Francisco and the southern parts of California, was impelled to instal a more modern system of coal handling.

Mr Robins has utilised his wharves by heightening and increasing the approaches, and erecting bunkers of great capacity close to the point of loading, thus preparing the way for the plant of Mr Wall, an apparatus which has been commended by the Minister of Mines of British Columbia.

The depth of the water at the docks is such that any vessel can lie safely alongside. The bunker capacity on and near the docks has been so extended as to be capable of holding a very large reserve stock. On these docks, the Company's engineer, Mr W. H. Wall, has designed and erected an ingenious loading apparatus which is worked by steam power, and which has greatly facilitated rapid loading. The speed at which a vessel may be loaded is only limited by the time required for trimming the cargo in the hold of the vessel. One of the Company's steamers, the "Titania," plying between Nanaimo and San Francisco, having suitable hatches, takes her full cargo and bunker coal, amounting to 6,000 tons, in twelve hours.

The coal-laden hopper waggons or trucks, each containing 5 to 6 tons of coal, are hauled from the bunkers to the approaches of the loading shoot by a 40-ton locomotive, each train containing twenty waggons. They are there left for dumping without further aid from the locomotive in shunting, &c., the locomotive being fully occupied in hauling empty and full trains to and from the bunkers and the mines.

In Fig. 388 may be seen the double tracks A and B, which serve each of the sets of loading shoots along the supply track A. The train of laden trucks is drawn by a grip dog to within one truck length of the end, where it is held in check by a safety stop which prevents the truck coming along the supply track until the carriage C is in a position to receive a truck. The dog then draws the end truck on to a transferring carriage, which is mounted on trolley wheels running on a transverse track, is pushed across the trackway until it registers with the parallel dumping track B, and unless unloaded into the first or highest shoot through the opening in the carriage, the truck is pushed by a piston-rod on to the dumping track, as far as the shoot opening into which its contents are to be dumped (suitable to the height of the water, see Fig. 389). When emptied, the truck is taken hold of by the double dogs situated on either side of the track (so as not to interfere with the shoot openings), and pushed along the dumping track, over the automatic lifter J, which secures the trap door of the truck when it is passed along to form a train of empties. In the meantime the transfer

* See *The Iron and Coal Trades Review*, 24th November 1899.

carriage has been drawn back by the piston-rod C^3 (attached to it and forcing it in both directions) till it registers with the supply track. The grip dog draws the train of

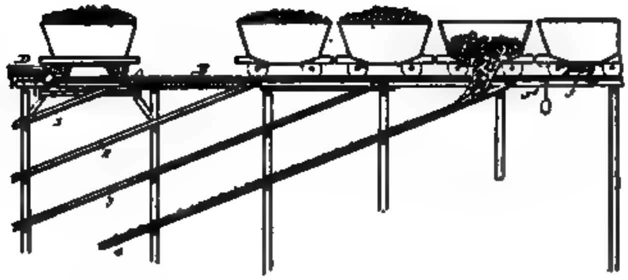

Fig. 388. Plan and Elevation of Wall's Coal-loading Device.

loaded trucks one truck length towards the end, and then forces a loaded truck on to the carriage, which transfers it to the dumping track as before described, the whole operation only occupying about twenty-five to thirty seconds per truck. The four levers work on specially constructed valves, and efficiently control the pressure. C^1 is an opening in C for dumping into the highest discharge shoot; C^3, piston-rod attached to the carriage, moving it in both directions; C^4, lever controlling pressure in D to piston-rod which forces the truck off carriage on to dumping track B; E, catch locking truck on carriage until it registers with track B; F, grip dog for moving trucks singly, or the whole train of loaded trucks along the supply track A; F^1, cylinder to operate grip dog F by piston rod F^2, controlled by lever F^4; G, G, grip dogs for moving trucks on dumping track B in a pair to avoid openings in the platform being openings into chutes; G^1, G^1, pair of cylinders to operate grip dogs GG by piston G^2; 1, 2, 3, 4, openings in platform for dumping into shoots for different levels of water; J, automatic lifter for trap door of truck, after dumping contents; K, stationary boiler, if required.

Fig. 389. General View of Wall's Coal-loading Device.

Fig. 388 shows a plan and elevation along the dumping track B, and Fig. 389 an application of the apparatus to loading a collier. The quantity of coal that could be thus dumped into a vessel can be placed at an average of 550 tons an hour for each loading shoot, and two shoots could be worked simultaneously at suitable distances apart to suit the hatches of the vessel. As many as 750 tons per hour have been loaded by one shoot.

The cost of loading say 5,500 tons of coal with a "Wall" apparatus is but 46s.

The plant may be driven by hydraulic power, steam, or compressed air.

According to the *Nanaimo Free Press*, the large steamer "Titania" was loaded in ten hours and thirty-five minutes, in spite of an accident to one of the loading trucks which occasioned a delay of half an hour.

It is said that forty years ago the time taken to load by a 1,000-ton vessel in this locality was between three and four weeks. This is not surprising when it is remembered that ships used to be loaded in those days by Indian women, who took out baskets of coal in their frail canoes which they handed up over the side of the vessel as she rode at anchor in the middle of the harbour.

A system not unlike the one just described, but much simpler, is in use at the Tyne Docks, near South Shields, and it is thus described in a paper read by Mr J. D. Twinberrow before the Institute of Mechanical Engineers:—

"Durham and Northumberland coals are transported in self-discharging railway trucks, the shipment being effected from timber staithes which contain hoppers fitted with spouts projecting laterally over the vessels lying alongside. Tyne Dock, near South Shields, in Durham county, holds the record for the monthly and yearly tonnage placed on board. The arrangement is entirely self-acting, the waggons being run down the central roads by gravitation. In passing the short length of sharp inclination they acquire sufficient impetus to travel through trailing points on the rising grade, by which they are brought to rest and their positions reversed. They then take the points leading to the hoppers where they discharge their loads and run back on the 'empties' road. The ease and rapidity of the process, the small number of men employed, and the absence of costly machinery are features which stamp this plant with the character of an engineering feat of the highest order. If such staithes were introduced into districts where the end discharging waggons are in vogue, the erection of a simple gantry over each hopper would enable these vehicles to tip their loads, so that they could be continued in service until gradually replaced by high capacity hopper waggons. Bogie waggons of any length could easily be accommodated, and owing to the diminished friction of large waggons fitted with axle boxes for oil lubrication, the gradient of the roads might be reduced." *

Rigg's Automatic Lowering Device for Coal.—This is illustrated in Fig. 390, and is intended to reduce the breakage of coal in its passage (too often unchecked) from the hatch to the bottom of the hold. This device is, in fact, intended to serve the same purpose as the anti-breakage boxes employed in connection with coal tips, a continuous chain of buckets receiving the coal in this case and conveying it to the bottom of the hold, thus avoiding an injurious fall.

The apparatus consists of a chain of buckets which intercept the coal as received from the ordinary shoots (see Fig. 390). The speed at which the chain travels is under control of a brake, motion being imparted by gravity. The chains of buckets are raised either by the ship's tackle, or by their own winches, should other power not be available.

* See "Capacity of Railway Waggons as affecting Cost of Transport," by J. D. Twinberrow (Proc. Inst. Mech. Engineers, 1900, page 573).

As the loading of the cargo approaches completion, as shown in Fig. 390, the necessity of the lowering device of course ceases.

This apparatus being lightly constructed of steel, is very portable, and can therefore be readily removed.

The Wrightson Coal Shipper.*—The illustration, Fig. 391, represents a device erected at the staithes of the Cramlingham Coal Co. in the Northumberland Dock on the Tyne. It was designed by Sir Thomas Wrightson, M.I.C.E., in conjunction with Mr Morrison, manager of the Cramlingham Co., and was erected by Messrs Head, Wrightson, & Co. Ltd., of Stockton-on-Tees.

The coal is in this case brought in at a high level and discharged into the hopper immediately above the level of the first conveyor. At the lower end of the hopper a

Fig. 390. Two Views of Rigg's Lowering Device.

door of sufficiently large dimensions to allow the largest pieces of coal to pass permits the tail end of the heap to run out on the slope upon the surface of the conveyor. This conveyor, in moving forward towards the quay, draws the coal gently down the slope through the door, filling the conveyor with a layer of coal of a certain thickness, which travels to the edge of the quay. It is at this point received by another conveyor mounted on a jib, the outer end of which can by gearing be lowered or raised to suit the level of the ship to be loaded.

The coal is carried on this second conveyor until it arrives at the end of the jib, the position of which is so adjusted as to plumb the hatchway. At the end of the jib are suspended a pair of vertical chains moving in a trunk; these chains have large trays

* See the *Engineer*, 6th and 13th August 1897; and *Iron and Coal Trades Review*, 3rd May 1901.

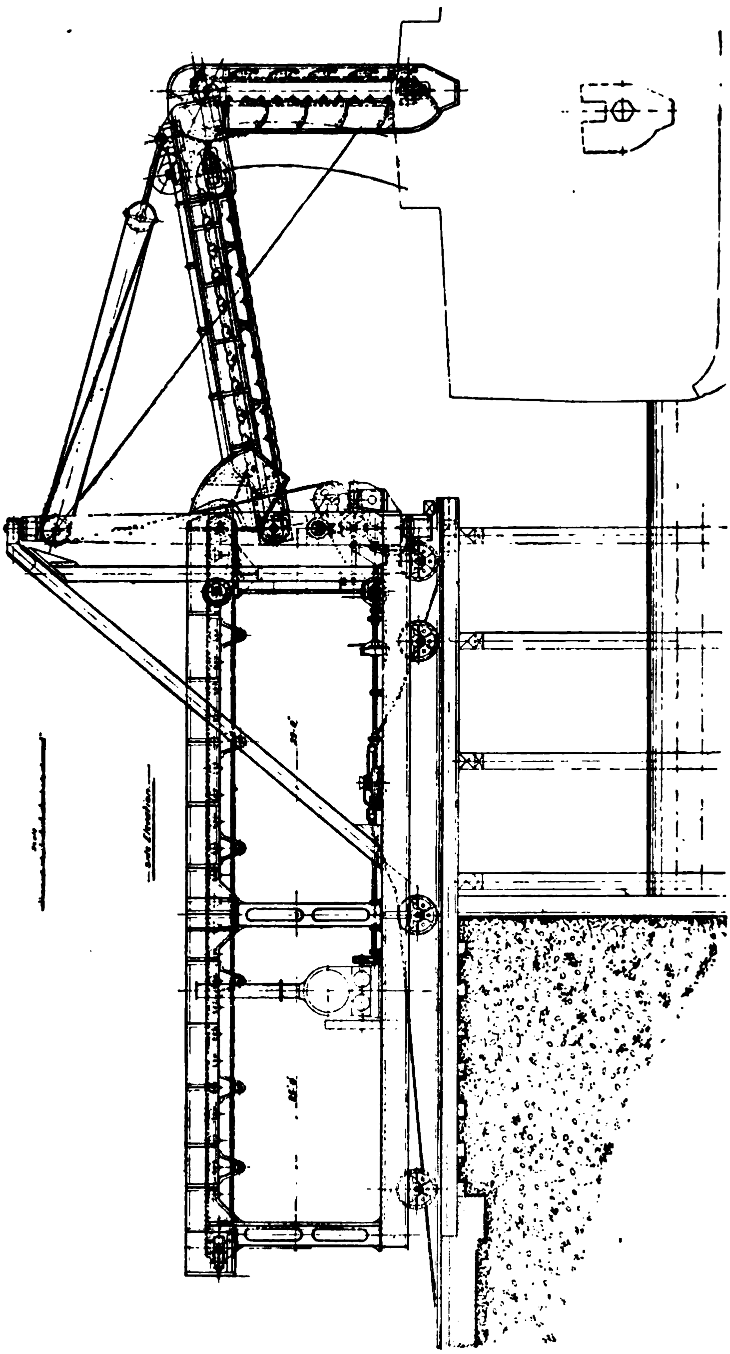

Fig. 391. The "Wrightson" Coal Shipper.

upon each alternate pair of links, and these in turning round the top drum form themselves into large hoppers, the back of the advance tray and the front of the following tray forming a hopper.

The coal from the end of the jib belt is directed into this naturally formed hopper. As the trays clear the top drum, they slide at an angle down the trunk, the coal being gently lowered until it reaches the level of the coal in the hold, where it discharges itself as the chain passes over the lower drum of the device.

The speed of the different conveyors is as follows:—The shore conveyor travels at 40 feet per minute, the jib conveyor at 60 feet, and the hanging conveyor at 52 feet per minute.

The whole machine is self-contained upon a platform which can be moved backward and forward by the same power that drives the conveyors. In addition to this loading of the coal, some of the trimming is effected by the machine, as the jib is so arranged as to slew right and left over a space equivalent to the length of the hatchway. The vertical trunk being upon the swivel joint at the end of the jib, can be deflected into a position which enables the coal to be delivered under the combings of the hatchway, thus saving a portion of the cost of trimming, and the further breakage involved in that operation.

The conveyors are all driven by an engine with a pair of 10-inch cylinders, the power expended being about 20 HP. The man in charge can control the speed of the conveyors as well as the raising and lowering of the jib, and the racking in and out of the platform, by means of handles and clutches placed in a convenient position. As an alternative to the retarding conveyor, a large rectangular or circular box or trunk can be suspended from the jib to receive the coal from the second conveyor. A large valve is arranged at the bottom of this trunk, which, on being opened, allows the coal to flow into the hold of the vessel at the same speed as that at which the top is being filled from the conveyor, thus keeping the trunk always full. This valve can be controlled by a cataract or other form of brake, and so made that after the trunk is emptied the valve rises to the top ready to receive the next supply of coal.

The "Hulett" Coal Tipper and Loader.*—Some remarkable machines for loading and unloading coal, ore, and other heavy materials have been designed by Mr G. H. Hulett, an engineer in the employ of the Carnegie Co., of Conneaut, U.S.A. One of these is the coal unloader at the Rochester and Pittsburg Coal and Iron Co.'s Docks at Buffalo, New York (see Figs. 392 and 393). This was specially designed for speedily transferring coal from cars to boat with a minimum of breakage, and without any increase in the working staff.

The loaded coal truck in this machine is drawn into the cradle, which is then turned upon a pivot until the car is inverted at the proper angle. As the cradle revolves the truck moves over against the side of the cradle and rests securely on it. No side clamps are required to hold it in position, as it is kept in place by chains passing over the top. To the free ends of these chains counterweights are attached of sufficient weight to hold the truck against the cradle. The operation of returning the truck during tipping is therefore entirely automatic. As the truck is inverted the coal slides out into the hood, there being no drop from the truck to this hood. As soon as the car is in this inverted position, doors in the end of the hood are opened, and the coal is discharged into two buckets. The lower ends of these buckets are cylindrical, with a diameter of 5 feet 6

* See *Colliery Guardian*, 18th November 1898.

inches, and they can be lowered to a distance of 12 feet through the hatches of small boats, and will go to the bottom of larger boats having hatchways more than 15 feet deep. The bottoms of the buckets are movable, and are drawn up through the shell of the

Fig. 392. Side Elevation of Hulett Tip and Loader.

Fig. 393. End Elevation of same.

buckets, and as the coal is discharged from the car to the buckets the bottom of the bucket is lowered at the same rate as that at which the buckets fill, causing very little, if any, drop from car to bucket.

Conveying appliances operated by winches are provided, one for each bucket, and

while the one car is being unloaded and run off, the next car is put in position on the cradle. The buckets are hoisted, run out over the boat, and lowered through the hatch until close to the bottom, when by holding the shell with one drum of the winch and lowering the bottom of the bucket with the other, the coal flows out, as shown in the illustration. The outer extension, overhanging the quay, can be swung out of the way as shown in dotted lines. The entire conveying appliance pivoted at the rear end of the structure is so arranged as to swing, and can thus be adjusted to hatches of different centres. Four men are needed for the manipulation of this machine.

As two hatches can be filled simultaneously, the boat is loaded in half the time that would be taken if a single shoot were used. The buckets also act as trimmers, distributing the coal well across the boat, and delivering it so evenly and gradually that breakage is thereby minimised.

The "Hulett" Unloader.—To clear open barges some grabs manipulated by a crane can be used which will discharge nearly the full contents of the boat, rendering hand trimming practically unnecessary, at the most two or three men being able to complete the work of the grab. In discharging larger vessels, however, which have narrow hatchways, the ordinary grab can only attack the material which is directly underneath the hatchway, the rest being trimmed up to the point which the grab commands.

To obviate this necessity for trimming, an attempt has been made by the American engineer, Mr G. H. Hulett, to construct a discharging apparatus which can handle the material lying out of its reach by drawing it towards the hatchway.

The appliance is on the same principle as that used for discharging grain out of awkwardly shaped holds and conveying it to the elevator, which dips vertically into the hold.

An apparatus of this description, known as the "Hulett" unloader, has been built by the Webster Camp and Lane Machinery Co., of Ekron, Ohio, U.S.A. The grab used is of a capacity of 10 tons, and is not, as is usually the case, suspended by chains, but is made fast at the end of a vertical iron arm which is capable of revolving on its axis at such an angle that when the jaws of the grab are open they will command a circle of about 10 feet in diameter. In this way, as soon as the grab has been lowered into the desired position through any narrow hatchway into the hold, it can be made to reach from one side to the other until the bulk of the hold is cleared, and so the work of trimming is greatly reduced. The man who controls the grab can take up his stand at a point low down, and can thus obtain a full view of his work. The jaws of the grab are operated by steam, the arm being suspended from a double iron framework with two sides, and this framework is pivoted to a cradle mounted on wheels which can be brought across an iron bridge as near to the edge of the water as may be necessary. All movements are effected by steam or by hydraulic power. When the grab has taken its load it is drawn up, pulled back, and discharged into the railway trucks beneath. The only staff required are one man working at the grab, one man at the travelling cradle, and a stoker, to which may be added a foreman and one trimmer. The capacity of this apparatus amounts to 2,500 tons in ten hours. It would appear that the first machine built did not answer all the expectations raised, because twelve to fifteen trimmers had also to be employed. This firm so far amended their original design that, the grab with its arm, even while attached to the main structure, may be worked quite independently.

The jaws of the grab command a radius of 15 feet. The grab is suspended from a

chain, and has a capacity of 2 to 4 tons per hour according to the nature of the material it is handling. It dips straight into the material under the hatchway, taking at once about 50 per cent. of its full load, while the rest is shovelled into its jaws by a scraper.

Fig. 394 shows this installation, which appears to be altogether a lighter and handier machine than the original unloader.

Soar's Coal-lowering Apparatus.—This apparatus is built by the Chain Belt Engineering Co.; it is illustrated in Fig. 395, and works as follows:—AA are hinged plates bolted to Ewart chains B, and work in the direction shown by arrows. The chains that carry the plates are driven by the Ewart chain C, which, when a picking table is used, is driven from the terminal of the picking table by means of spur wheels. The driving chain C passes over the driving wheel round the tension pulleys DD over the top and bottom terminals E and F. As the chain C cannot slip, the relative position

Fig. 394. General View of Hulett Unloader.

of the plates to the screen or picking band is not affected during the process of lowering or raising the apparatus.

The shaft E works in two slide blocks G, which slide between guide bars HH. Bolted to these guide bars are two distance bars KK which carry shaft F.

The apparatus is suspended by chains with counterbalance weights over chain wheels MM, and is raised or lowered by winch O.

The hinged plates lower the coal after the manner of an inverted elevator, and afterwards fold up on their hinges on the return side, so that the coal can be taken very nearly to the back of the waggon. This appliance is certainly an advance upon the others, so far as its facility for getting into the waggon is concerned, but, though dealing satisfactorily with coal of a moderate size, it is not well adapted for handling very large pieces.

The Hoover & Mason Ore-handling Plant.—This very interesting plant has been installed at the South Works of the Illinois Steel Co., U.S.A., and the makers, Messrs Hoover & Mason, Chicago, claim that it has solved problems which have con-

fronted engineers for years past. They point not only to the quick discharge of the ore from the hold of a vessel, but also to its stocking in the blast furnace yard, where it is always readily accessible: to its economical handling by means of the bin system, in connection with coke and limestone, and to its continuous delivery at the top of the blast furnace.

This plant has now been in operation for some time, and comprises a complete equipment for receiving the ore by water, unloading it from the vessels, stocking, and finally delivering it to the furnaces.

The main feature of this plant is the attempt to utilise to the fullest extent the peculiar position of the furnaces, which are directly served by lake steamers, a considerable portion of the ore coming straight from the mine to the furnace.

Fig. 395. Side and Front View of Soar's Loader.

The general outline of the scheme is shown in the plan, Fig. 401; and to a somewhat larger scale in the elevation, Fig. 396.

A long line of unloaders, fifteen in number, is placed at the dock front, thus making it possible to simultaneously attack every hatch in a large lake vessel. Each unloader manipulates a 5-ton grab, operated by one man, and makes sixty trips per hour, giving a gross capacity to the first half of the vessel of 3,000 tons per hour.

The unloaders deliver the ore into trucks for carriage to distant points, or into the adjacent concrete trough in their rear. In this manner, practically the first half of the cargo is discharged in the first hour.

The residue of the cargo has to be brought to a point beneath the hatchways before it can be taken out by the grabs. This is effected by a series of scrapers, one at each

hatch, operated by an engine installed on the unloader on the shore, which controls the scrapers by light ropes from the hold of the vessel.

The diagram, Fig. 397, represents a part section through the vessel; whilst Fig. 398 is a part plan of the vessel showing method of mechanical trimming.

The scraper has a resemblance to a giant hoe, and weighs more than a ton. Its form is shown in Fig. 399.

The ore is moved by alternately moving this scraper backwards and forwards, the point to which it returns empty being regulated by changing the position of the sheaves as shown in the plan view of the vessel, Fig. 398. Thus the entire cargo can be unloaded without hand labour. The discharge of the cargo, with the necessary clean up to get the vessel ready for another cargo, has been accomplished in four hours.

The unloaders receive steam from the blast furnace boilers through a line laid in a conduit and along the dock front in a tunnel within the concrete trough construction, each unloader being connected with the main by a flexible pipe.

These unloaders have a large capacity, and it is reported that no less than 160 tons have been discharged by one man in half an hour.

As regards soft or hard ores the capacity differs but little. The work of stocking the ore or transferring it direct from the vessel to a trough 600 feet long immediately in the rear of the unloaders, or from the stock pile to the furnace pockets, is accomplished by means of two high-level cranes, each 520 feet long, which are traversed by electric trolleys, each of which contains mechanism for the control of 10-ton grabs, and commands all the various materials for the furnace, including a reserve stock of limestone and coke. Each crane is controlled by a single operator, who can at will pick up 10 to 15 tons and transport it to the furnace hoist, the hoisting speed being 100 feet per minute, while the conveying speed of the heavy trolley is 1,000 feet a minute.

Street-car electro-motors, with brakes and controllers, are used throughout the installations, two 125 HP. Westinghouse railway motors accomplishing the digging and hoisting, whilst two of 35 HP. give the transverse motion to each trolley.

The current is transmitted to the trolley by conductor rails, one being placed on each side of the bridge, about 23 feet apart. Two cast-iron shoe collectors are provided to each rail, in order to prevent sparking under maximum demands of 900 amperes.

Fig. 396. Elevation of Hoover & Mason's Ore-handling Plant.

At each end of the bridge provision is made against a runaway, in the shape of twelve Westinghouse friction drawheads which act as buffers. These have been found very efficient in checking these heavy trolleys. The bridges rest upon standard gauge tracks, placed upon concrete walls 33 feet high. The crane itself has a novel function in respect to its movement, having the capacity to assume positions not necessarily at right angles to the axis of the supporting tracks. One end of the bridge may thus be kept stationary while the other end is moved a distance of 300 feet, thereby giving an elasticity to the work which is highly desirable.

In this way all the operations at the furnace side of the ore yard may be effected without moving the crane upon its track. The total weight of each truss, including the

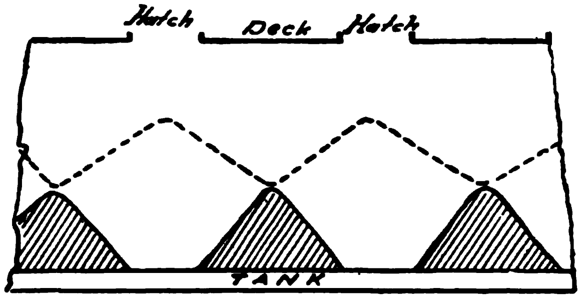

Fig. 397. Part Section through Vessel.

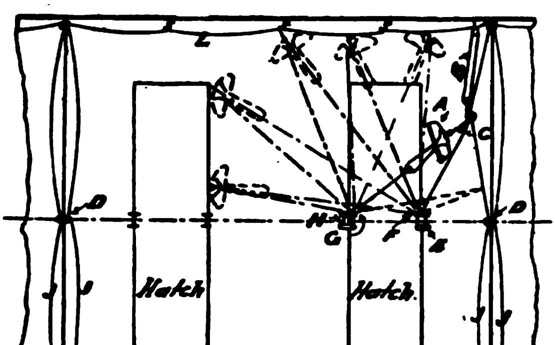

Fig. 398. Part Plan of Vessel showing Method of Mechanical Trimming.

EXPLANATION OF LETTERING.

A, Scraper.	G, Sleeve Nut.
B, Pull-back Tackle.	H, Stanchion.
C, Bulkhead.	J, Bulkhead Pennant.
D, Middle Bulkhead Hooks.	K, Double Eyebolt for Bulkhead.
E, Stanchion Bulkhead Bracket.	L, Side Pennant, ¾-inch Rope.
F, Stanchion Block.	M, Hold-back Hooks.

supporting trolleys, is about 450 tons. The supports for each truss over the walls are as follows:—On each trolley is a turntable, similar to a swingbridge turntable, but the trusses also rest upon a nest of parallel rollers on the south walls, which permit of a variation in span length due to the obliquity resulting from the angular movement of

the bridges. During the time the crane is traversing the length of the ore yard the work of excavating and delivering is not interfered with, both operations proceeding simultaneously.

The furnace pockets shown in Fig. 400 have a capacity of 3,000 tons of ore, 1,000 tons of coke, and 500 tons of limestone. These are double pockets, the south tier being almost entirely used for the storage of coke and stone and the north tier for ore. A large portion of the ore is conveyed direct to the pockets by the crane, but as the ore yard could not be placed symmetrically to the furnaces, a transfer car became necessary. This bridge is of such large dimensions that the bridge operator can forthwith deliver his load of 10 tons taken from the trough or from the stock heap.

The grab, when open, commands an area of 19 feet and a width of 6 feet. The skewing of the ore bridge, which brings the grab in position across the line of the axis of

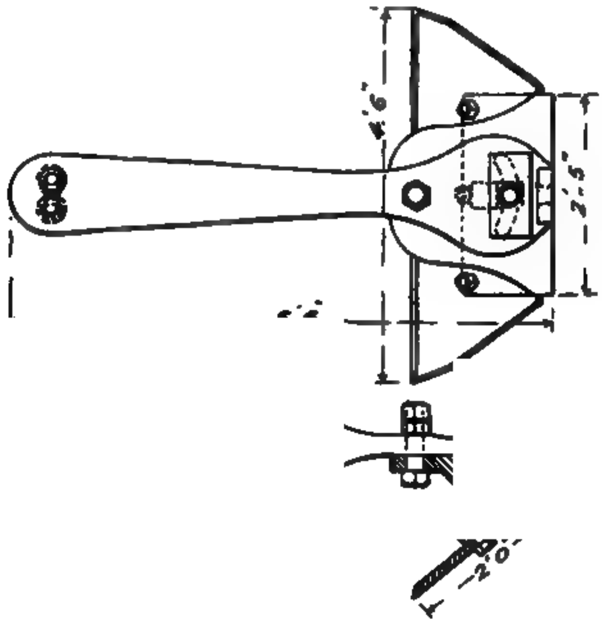

Fig. 399. Plan and Section of Scraper used in connection with Hoover & Mason's Ore-handling Plant.

the pockets, necessarily affects the size of the car. The body of the transfer car is 26 feet long by 18 feet wide.

The dumping or discharging is effected at the side, the opening of the doors being effected by gravity, while they are closed by a small motor. To avoid danger of collision with scattering lumps of ore the operator's car is placed upon a sort of outrigger. The size of the car permits of the ore being delivered to either side of the pockets. The car body is of great weight, and thus the shock of receiving a mass of 15 tons is minimised. The car is electrically operated by one man who travels with it, controlling it by ordinary tram-car devices. The ore pockets were constructed of steel throughout, and designed to prevent the formation of arches in the ore mass and consequent interruption in the feed. The sectional view, Fig. 400, shows how this is accomplished by louvres. These louvres also afford access to the pockets in the case of a few very sticky ores, which,

despite the louvres, have a tendency to choke. The withdrawing of ore from the pockets is effected by a rotating cylinder 5 feet in diameter. The aperture for the exit of the ore is in all cases equal to the width of the pocket, so that the ends of the pocket are vertical. When it is desired to withdraw ore, these rollers are set in motion, forming a feeding

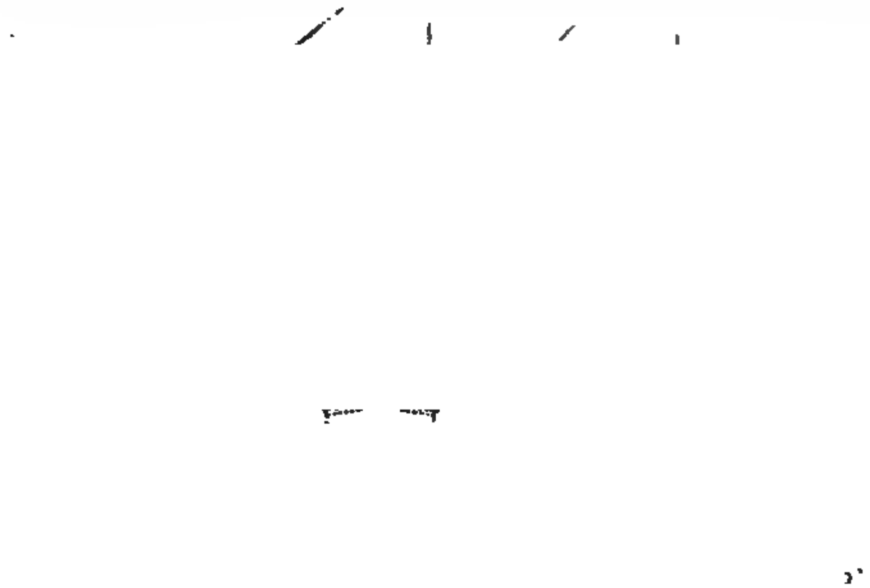

Fig. 400. Showing Hoover & Mason's Ore and Coke Pockets and Scale Car.

device which carries the ore out of the pocket, and to a considerable extent loosens up the mass within the pocket. These rollers are actuated by a motor-driven continuous running shaft, which can be geared to the rollers by a friction clutch.

The rollers on the coke side are perforated, and efficiently act as screens in separating the dust from the coke (see Fig. 400).

A hot-air chamber is placed under the ore bins in order to prevent their contents from freezing in cold weather.

One weighing truck only is needed for each furnace. In the course of a year one man has kept a large furnace full without difficulty. Each weighing truck has two compartments, each holding a skipful (see Fig. 400). All material delivered to the furnace is weighed before entering the skip. The weighing truck is driven by electricity. The weight of each increment is recorded upon a strip of paper by the balancing of the beam, and is thus placed beyond the reach of any tampering, an unimpeachable record being kept of the total weight of material fed into the furnace. The coke is distributed

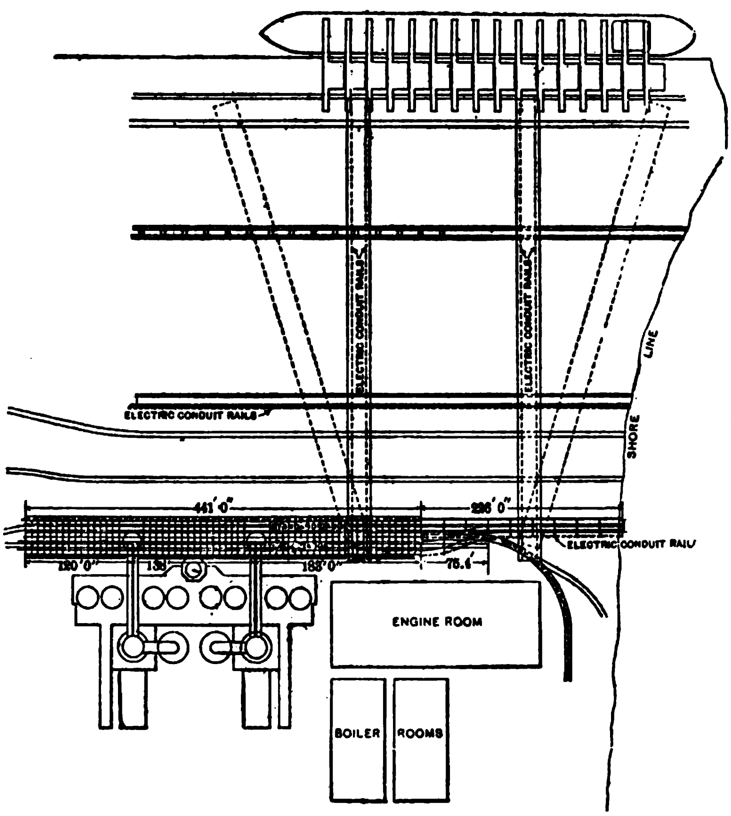

Fig. 401. Plan of Hoover & Mason's Ore-handling Plant.

along a considerable length, and not, as is often the case, into two large ore bins, delivering directly into the skip. The advantages of this plan are, firstly, that it enables a large number of coke cars to be run over the pockets and unloaded simultaneously; secondly, it obviates the drawback of these large pockets, as the proportion of dust entering the furnace at one time is minimised; thirdly, it is found that by putting the coke through a weighing truck the dust therefrom prevents the ore from sticking to the truck, and thus quickens the discharge. The fact that one man can maintain the furnace shows sensitive and rapidly delivering pockets. The operator need not quit his station for any purpose. He can control either truck or pockets from one position, pendant cords somewhat like a bell-rope being conveniently placed, and by

simply pulling the rope he can, in a few seconds, load his car. The load on the car is indicated by a hand on the dial. Buttons of different colours are placed on this dial, each button corresponding to a load of ore, coke, or limestone. The operator pulls the cord until the index finger travels to its proper position; he then releases it, and the charging ceases.

In both the 5 and 10 ton grabs the path of the cutting edge through the material and the inclination of the tray follow certain lines which it is claimed have been found most efficient for digging ore. The construction of these grabs permits of the path being altered so as to suit any given material. It may be of such a character as to make an even cut of 6 or 8 inches below the surface over the area contained in the closing stroke, or a cut to any other depth (within certain limits) that the nature of the material may call for. The ore trough is essential for two considerations; firstly, in the event of its being desired to speedily discharge a vessel, as the shorter the distance the ore is moved the more quickly this will be accomplished; secondly, the stock pile should at all times be accessible to the conveyor which takes the ore to feed the furnaces. All ore taken from the vessel's hold, except such as is immediately dropped into trucks for carriage to more distant points, is unloaded into the trough at the rear of the unloaders, and thence is distributed by the 10-ton grabs into the stock yard or directly into the pockets situated near the furnace. Thus the fifteen 5-ton grabs can be constantly at work removing the ore from vessels, whilst the 10-ton grabs can either be feeding the furnaces from the stock pile or removing the ore from the trough to the stock piles.*

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* The author is indebted to the *Iron Trade Review*, of Cleveland, Ohio, and to the *Iron Age*, of New York, for the above description.

CHAPTER XXIV

AUTOMATIC LOADING DEVICES.

These appliances are largely used in gas-works and other factories, and they are usually installed at points where minerals, coke, artificial manure, &c., have to be loaded into railway trucks or other vehicles. They are often of great utility in loading railway trucks when the latter cannot be loaded by gravity.

Installations of this kind are as a rule more common in Continental gas-works than in gas-works in this country. Many of these plants have been designed by C. Eitle, a few of which installations are here described.

The plant shown in Fig. 402 represents one of these appliances.

This consists of a light iron framework with a corrugated iron roof. The coal to be loaded is either conveyed mechanically or by hand into the elevator well, and is from there lifted to a suitable breaker and then conveyed to a sieve which separates the material into three sizes, small, medium, and coarse. The two finer of the separations are generally drawn off in smaller trucks, whilst the larger-sized fragments are loaded into railway trucks or other waggons.

This installation is very compact, and is driven by a gas or oil engine. It will be seen from the illustration that a swinging conveyor is used for taking the large coal to the railway trucks.

Fig. 403 is a modification of the same design.

The principal difference is this, that the second installation consists of two elevators, one to receive the load as in the previous case and deliver it to the breaker and sorting sieve, whilst the second elevator serves to take the coarse material from the sorting sieve to the railway trucks.

The plant, which is illustrated in three views, is specially adapted for use where the railway siding is on a higher level than the factory yard, and where there is not sufficient headroom for such an installation as that shown in Fig. 402.

Fig. 404 shows a similar plant which is suitable in cases where the material is already of a uniform size and need not be further treated by breaking rollers.

Fig. 405 shows a portable appliance of this class, consisting of an engine, counter-shaft, coke-breaker, and elevator, the whole of the plant being suitably placed in a covered truck, running on a standard gauge track. It is pushed in position between, say, the coke heap of a gas-works and the cart or railway truck to be loaded, the coke from the heap being thrown into the opening visible just above the breaker, where it drops into the elevator well, and is delivered into the truck or waggon. The breeze produced is separated by means of a screen between the breaker and elevator.

These portable elevators, combined with sifters, and sometimes with coal-breakers, are not unfrequently met with in Continental gas-works. They are employed for taking the coal from the heap in the yard, and automatically breaking, sifting, and delivering

Fig. 402. Classifying and Loading Device for Railway Sidings

Fig. 403. Classifying and Loading Station with Two Elevators.

it to the cart or railway truck. The same device serves for handling coal and minerals of all kinds which are stored in stock heaps in the open.

The next illustration, Fig. 406, shows a further appliance in two views.

Fig. 404. Small Loading Device for Railway Sidings.

This apparatus is placed as near the stock heap as possible, with the elevator in a perpendicular position. The motor which drives the elevator and the sieve is then

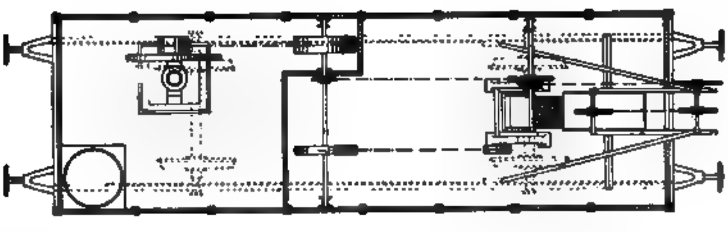


Fig. 405. Portable Classifying and Loading Device.

started, and the elevator pushed forward into the heap by a winch as shown. The dotted lines show the elevator in a raised position. The coke or coal breeze which has been

sifted out drops into baskets or other receptacles. This appliance will handle 20 tons per hour, and is undoubtedly a great labour-saver.

Fig. 407 shows another and more complete installation. This apparatus is seen in longitudinal section as well as in cross section on the line AB.

The material to be handled is deposited in the elevator well which projects in front

Fig. 406. Portable Loading Device for Taking Coal or Coke from Stock Heaps.

of the car, and the elevator lifts the coke into a breaker from which it drops through an oscillating sieve into the second elevator. The dust removed by the sieve falls out through the side shoot shown in the illustration in both views.

The second elevator delivers the coal into the hopper, from which it is measured by

Separate Engine-room

e a weighing machine could be sub-
l by measure, this appliance is most
hich is shown in a separate motor-
ng apparatus to the railway truck is
which is exactly adapted for loading
delivery shoot which can be put in
s.

In cases where there is only one line of rails, the "swinging" conveyor can be so arranged as to project at the end of, instead of the side of the truck.

A similar but less elaborate device is that shown in Fig. 408, which gives two elevations of the same.

Fig. 408. A Further Form of Portable Loading Device.

MISCELLANEOUS.

CHAPTER XXV.

THE AUTOMATIC WEIGHING OF MATERIAL.

When handling material automatically, it is often desirable to keep a record of the weight thereof; also the total tonnage, so as to check deliveries of coal, grain, &c. It is also essential to keep a record of the contents of vessels filled mechanically, as well as of silos, bunkers, barges, and other receptacles.

Automatic weighing machines which are used as a means to this end may be classified under three headings.

In one type the material is weighed at the point of receiving from or delivering to the elevators or conveyors which handle the material, in which case it actually passes through a weighing machine. A second type of weigher is attached to certain kinds of conveyors, and records the weight of the passing load without bringing the material itself in contact with the hopper of a weighing machine. There is also a third type of weighing machine which is used for weighing material intermittently in larger quantities. There are advantages and disadvantages in each method. In the first type A, known as **Hopper Weighing Machines,** the record of the weight is more accurate. This is of course an important matter if material of a valuable nature is being handled, but these machines have their limitations. To begin with, the material to be weighed must be of a fairly uniform size, that is to say, big pieces must not be mixed up with small particles. Then again, these machines generally necessitate considerable headroom, which is not always available. This is necessary because a stationary hopper must be provided into which the elevator or conveyor can deposit the material before feeding it into the weighing machine, and there must also be a second hopper beneath the weighing machine to receive the material leaving it. In addition to these two hoppers, the height of the weighing machine itself must be taken into consideration. This difficulty may be overcome by the use of an elevator, but there is also the drawback incidental to the breakage of friable material, and the consequent production of dust. In the case of coal the last objection would probably be the most urgent.

The second type B, known as **Continuous Weighers,** require no extra headroom, produce no dust, and are not calculated to triturate the most friable material; but on the other hand, the record obtained is not so reliable as that of the hopper weighing machines.

The action of the first and second types is more or less continuous, as a constant stream passes through both kinds of weighing machines. Even with a hopper type the delivery can be made to a certain extent continuous.

C, known as **Intermittent Weighing Machines.** This third type is for the purpose of weighing material contained in skips, buckets, or trucks, which, during the

conveying process, pass a certain point where the weighing apparatus is stationed. Such appliances can, however, only be used successfully when the tare of the receptacle is known and has been adjusted to exactly the same in all the units which may be used for the conveyance of the load. The weighing machine itself generally weighs each separate lot, and adds the successive weights up to a total.

In selecting a weigher it is of course necessary to take all the conditions into consideration. Broadly speaking, it may be said that the hopper weighing machine is most suitable for grain, seeds, small coal, &c., the continuous weighing machine for coal and minerals, whilst with the intermittent weighing machine material of any kind may be conveyed in the receptacle passing over the weigher.

A. Hopper Weighing Machines.

The "Chronos" Automatic Grain Scale.—This was the first machine for the purpose of automatic weighing, and is the design of Messrs Reuther & Reisert, of Hennef-on-the-Sieg, Germany (see Fig. 409).

This weigher consists essentially of a beam scale A, of the usual kind, with arms of equal length, to one of which is suspended the weight C, and to the other a skip B, for the reception of the grain, such a skip being capable of rotation on an axis, and being provided with two apertures for the respective operations of receiving and discharging, whilst from the other arm there also hangs a beam board which will take any ordinary kind of weight.

Over the recipient is placed a hopper D, while underneath play two valves or rather gates which regulate the flow of feed. The grain, pouring through the hopper, soon fills up the recipient B, until suddenly the upper gate partially closes, thus shutting off the greater part of the feed, and letting in only two thin streams of grain, which together make up the exact weight set on the beam board. As soon as that point has been reached, a stud attached to the pointer of the beam scale comes in contact with a toggle joint PML, which serves to support the second flap and bends the former down. The effect of this is to completely close the inlet, while simultaneously a hook, which has kept the recipient in an upright position for taking in the feed, is released. The skip then tips forward about 40 degrees, this movement being sufficient to empty it of its contents, but as soon as this has been accomplished it regains its former position, the index X registering the weighing, whereupon the two inlet valves are opened, and it is again held fast by the hook. With the re-entry of the feed the operation already described is repeated. Each revolution of the skip, and therefore each discharge of a given weight of grain, is registered on a dial attached to the front of the scale. The two illustrations, Fig. 409, give a clear idea of the movement of the skip B, as well as of the action of the "Chronos" machine.

To reduce friction to a minimum and to ensure smooth work, it has been the aim of the makers of this machine to shorten as much as possible the arc traversed by the skip in its tipping motion, hence it had to be provided with an outlet distinct from the inlet. Moreover, the recipient has been so shaped and hung, that while the grain, seeds, or other materials are being fed through the inlet, the bottom of the skip remains in a horizontal or nearly horizontal position, while, during emptying, the angle is slightly more than the angle of repose of the grain.

The weight of the outward flap is sufficient to keep the discharge opening shut during the filling operation, while it swings forward and allows a free passage to the discharging grain as soon as the angle is enlarged by the revolution of the recipient. Meanwhile the discharge gate has fulfilled its appointed function in preventing any portion of the grain from spurting outwards and escaping before the right time.

The setting of the scale appears to be a very simple operation. By a turn of a small lever the mechanical parts of the weigher and the beam scale are entirely disconnected. The beam will then swing loose like the beam of an ordinary scale, while

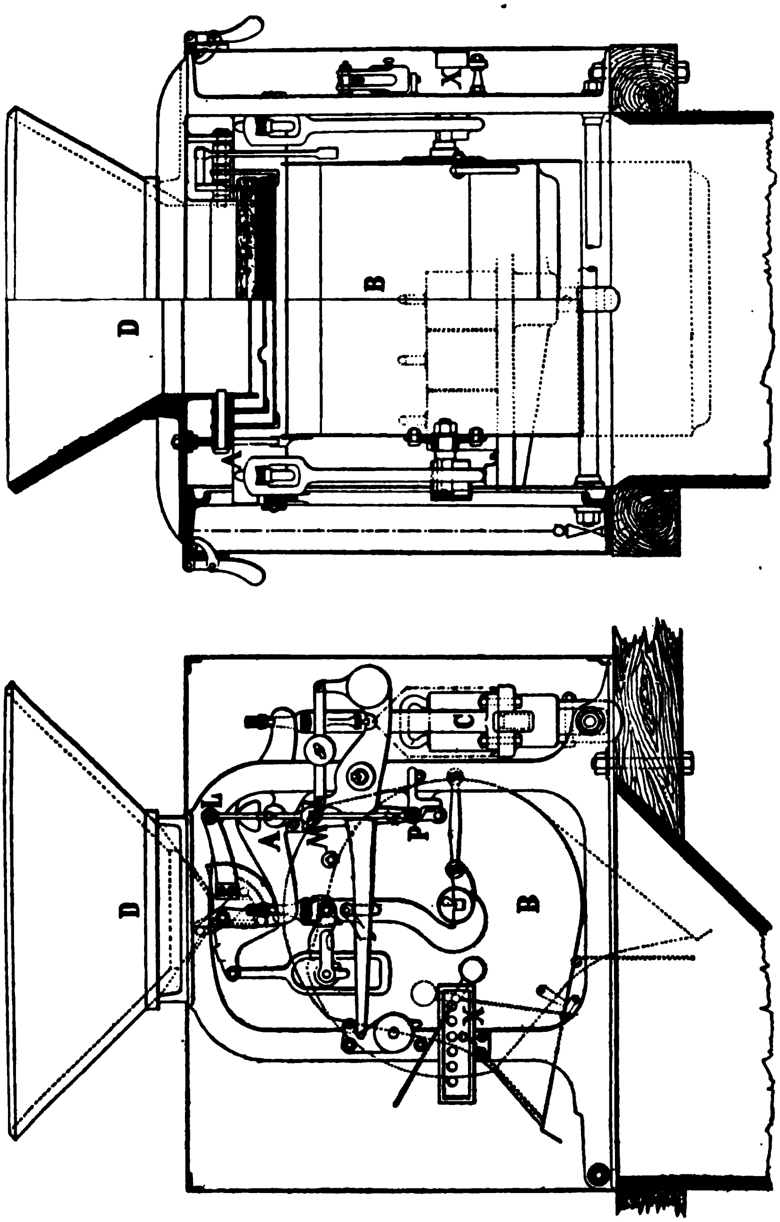


Fig. 409. View of "Chronos" Grain Scale, showing Action of Skip.

the pointer will play freely whether the board be weighted or not. It is thus easy at any moment to test the weigher by means of its own scale, and this operation can be effected in a few seconds without in any way interrupting the work. If any discrepancies should be manifest in the weighing, they can be corrected by the

adjustment of a small weight, and when once this weight has been set in its proper position, the machine will weigh accurately and continue to do so.

If desired, the whole apparatus can be covered by a sheet-iron casing, which will leave no part exposed except the glass face of the dial register. The casing can then be locked, thus effectually removing the possibility of any tampering.

This machine is built in eighteen sizes, for charges from 12 to 3,300 lbs. of grain, and with a corresponding capacity of from 32 to 3,240 cwts. of grain per hour.

The "Nomis" Automatic Beam Scale.—This machine is built by Richard Simon, Nottingham. It is of very simple construction, and is illustrated in Fig. 410, which shows front and side elevation of the machine with the inlet and delivery skip. The side elevation shows the grain hopper both in its normal position and when empty, and also in dotted lines the position it takes during discharge.

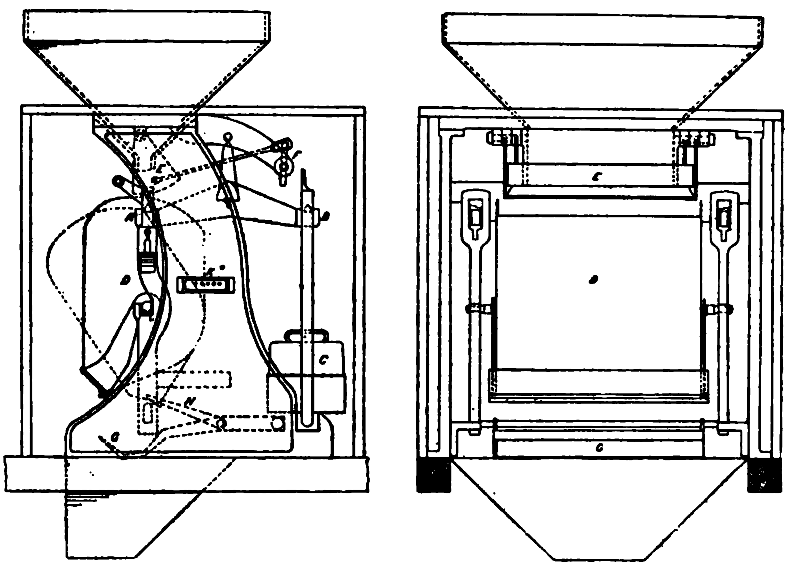


Fig. 410. "Nomis" Automatic Beam Scale.

This machine is a beam scale, having equal arms AB, with a standard weight C suspended from the end B of the beam, and the receptacle D hanging from A at the opposite end. Above is a valve arrangement E, which admits grain and other similar substances, and also cuts off the flow when the correct weight has been admitted. The mechanism used to obtain this result is very simple. A side weight acts, together with the skip D, and the inflowing weight of grain, to overcome the inertia of the dead weight on the other arm, and to shut the first of the two valves, so that the inflowing grain is reduced to two small streams when the correct weight has been nearly reached. The adjustable side weight compensates for the stream of grain in the act of falling at the moment of closing the valve. The final cut-off is caused by the rising of the arm B of the scale with the weight C, as the grain recipient descends.

A steel pawl lifts the crank F coupled direct to the valve E, so that as soon as the crank is over the dead centre, the weight of the valve is called into action to close itself. After closing, the valve moves forward sufficiently to release the catch supporting

the skip D, which, being pivoted somewhat below its centre of gravity, immediately tilts, and in so doing uncovers the discharge opening at the bottom through which the grain leaves the bucket. The discharging wheat strikes a rocking plate G, secured to the frame of the machine. This brings down a hook H, which holds the bucket in position until it has emptied itself, after which it is released and swings back to be refilled, closing itself and opening the inlet valve by its momentum, while simultaneously it actuates the counter K and so registers the weighing.

Should the discharge spout from the weighing machine become blocked, the machine stops automatically and recommences work as soon as the accumulation has subsided. The short substantial beam of the machine secures rigidity and reduces vibration, which means that the oscillation during the weighing is reduced to a minimum. It also facilitates a quicker succession of weighings, as many as four per minute having been accomplished. This machine is chiefly used for weighing grain and seeds. It is built

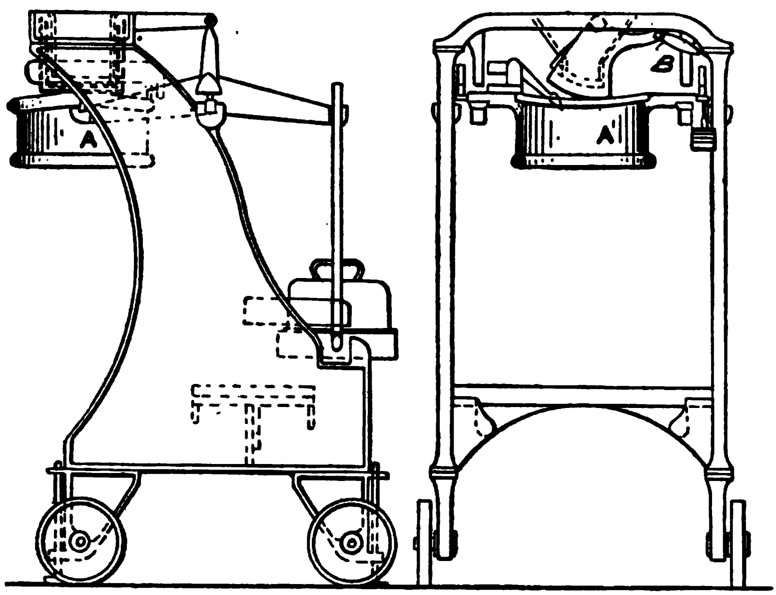


Fig. 411. Simon's Bag Filling, Weighing, and Recording Machine.

in ten sizes, having capacities of 2 to 500 qrs. per hour, and ranging in height from $12\frac{1}{2}$ to $89\frac{1}{2}$ inches for the different sizes.

Automatic Bag Filling, Weighing, and Recording Machine (R. Simon's).—A modification of the machine just described is illustrated in Fig. 411.

Instead of the weighing hopper, a bag is attached to the machine which serves for sugar, flour, coffee, rice, grain, seeds, &c., ordinary standard weights being used. It is claimed for it that it is a great labour-saving device, and is sufficiently accurate for most practical purposes. There is a counter in connection with it which records the number of sacks thus filled and weighed. All that the attendant has to do is to attach the empty bag to the cylinder A, and pull down the handle B, whereupon the sack is automatically filled with the correct weight. It can then be tied up and another one attached. This portable weighing machine should be of great service under silo

floors where grain from different silos has to be filled into sacks, as it can be put in position under any silo, and connected by a sleeve or temporary spout with the hopper bottom.

Avery's Automatic Grain Scale.—The action of this machine being somewhat intricate, a full description is here given. This automatic weigher (Richardson's patent) is built by Messrs W. & T. Avery Ltd., Birmingham. It is illustrated in Fig. 412, which shows two views of it when empty.

A^1 and A^2 are the side frames to which are fixed the main bearings A^5 and A^6. In these rest the knife edges of the beam B, on which is suspended at one end the iron box D, and at the other end the recipient C, in which the grain is weighed. It is so arranged that the box D exactly balances the skip C, and being made with a sloping top, no dust, &c., can enter therein. C is of the required size to hold the quantity to be weighed at each discharge. The box D has a hinged lid, which can be fitted with a lock to prevent any tampering with the weights. The skip C has a door C^7 at the bottom which is automatically opened and closed as required. The supply of grain is regulated from the spout F by a weighted valve G, which is hinged at G^1, and has an aperture G^3 in its front edge. The pin G^2 attached to the valve G works in the slot H^3 of the lever H^2, so that when the locking levers H^1 and H^2 are down as shown, the valve G is prevented from opening. These locking levers H^1 and H^2 are connected with a lever L by a weighty rod K fitted with a steel roller K^1, which, when the rod is raised, rests on the roller M^1 fastened to the trigger M, the latter being so pivoted as to swing underneath by its own weight.

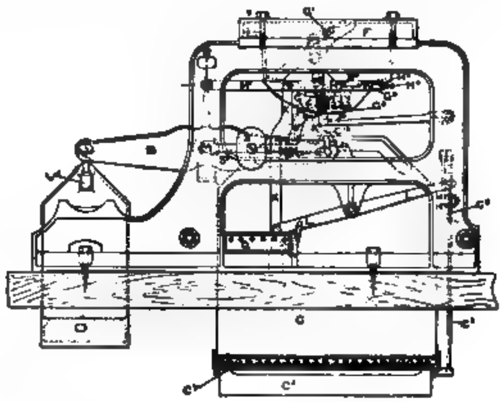


Fig. 412. Avery's Automatic Grain Scale in Two Views.

The door C^7 at the bottom of the skip C is kept closed during the weighing operation by the bar C^3 attached to the toggle C^6. This toggle is pivoted to the hopper and fitted with a striking bolt C^8, which, when the scale is required to weigh automatically, is drawn out until it overhangs the lever L. The door is so arranged that, when open, the weights C^5 and C^6 exert only a slight tendency to close it. Thus a few grains of wheat at the top will keep it open, and automatically stop the machine from working until the skip C is empty. The action of the scale is then as follows:—

On the weight required being placed in the box D, that end of the beam B is lowered until the projections V^1 rest on the side frames A^1 and A^2. The other end of the beam

rises, and by means of the projection C^{12} engages under a pendant P, and attempts to lift the valve G, but being prevented by the locking levers H^1 and H^2, it only compresses the pendant spring B^2, which causes the box D and the weights to descend gently without any jar to the machine.

Then on the free end of the lever L being depressed, the other end raises the rod K and breaks the locking joint formed by the levers H^1 and H^2. This frees the valve G, which, owing to the pressure of the spring B^2, opens wide, lifting the levers H^1 and H^2 with it, and admitting a copious stream of grain from the shoot F. This goes on until the weight of the grain in the skip C, assisted by the weight of the valve G, depresses the beam B until it no longer supports the valve, which closes again as far as allowed by the pin G^2 in the slot H^3 of the lever H^2.

The levers H^1 and H^2 are now supported by the rod K resting on the roller M^1 in the trigger M. The grain now entering the scale is only such as can flow through the small aperture G^3, and this quantity can be adjusted by means of the screw H^4 regulating the length of the slot H^3. This "dribble" of grain proceeds until the weight in the skip C is equal to the dead weight in the box D, when the beam comes down to the horizontal, and by means of a projection C^{10} draws away the trigger M from beneath the rod K, which falls on to a stop, bringing the levers H^1 and H^2 with it. The latter by means of the pin G^2 completely shuts the valve G and locks it as before. The falling of the rod K raises the free end of the lever L, which, by catching the striking bolt C^8, opens the door C^7. This remains open until all the grain has been discharged, when it swings to again, while the striking bolt C^8 coming down, presses the lever L, and starts the whole operation over again.

It will be noticed that when the weight of grain in the skip C exactly balances the weights in the box D, the valve G immediately shuts, but the grain in suspension at the time falls into the skip and would be overweight were it not compensated for by an adjustable weight S on the bar S^1 which rests on the beam during the weighing operation, but afterwards catches a stop on the frame so that the beam finally swings clear of all the working parts, and conclusively proves that there is a perfect balance.

Q is the ordinary register or counting apparatus, so attached to the lever L as to keep a record of the number of weighings performed by the scale.

Fig. 413 shows one way in which the Avery weighing machine is installed in warehouses, &c., for the purpose of weighing grain in bulk. The grain is received, elevated to the top of the warehouse, and carried by means of band or other conveyors to the silcs. The illustration shows the elevator, and also indicates the position of the weighing machine between this apparatus and the conveyor which further disposes of the grain.

The scale is placed on a suitable staging, and fitted with a feed hopper above and a discharge hopper below, each of which are of a capacity slightly in excess of that of the skip of the machine. The spout from the elevator leads into the feed hopper, and after the grain has passed through the scale and been weighed and registered, it drops into the discharge hopper, whence it falls gradually on to the conveyor which distributes the grain to the silos. The opening in the hopper can be so adjusted as to feed the conveyor gradually.

This machine is built in twenty-four sizes, from 12 to 96 inches in height, the respective capacities for the different sizes being from 10 to 12,000 lbs.

The Avery Automatic Machine for Provender Mills.—The automatic weighing of chaff is admittedly difficult, because the extremely light nature of this

material necessitates a large quantity in the weighing hopper before any weight and consequently power can be obtained, and also because chaff from its nature will not run readily in spouts and hopper-shaped receptacles. For these reasons many forage and provender mills have hitherto employed measuring devices for chaff, the grain being added in the proper proportion by means of weighing machines.

Fig. 414 shows an installation in which Avery weighers are used both for chaff and grain. Such installations are now at work both in this country and abroad. In this case there are two machines. When it is desired to weigh chaff it is usually for the purpose of obtaining the correct percentage of chaff and corn in a mixture of the two for feeding purposes. The small machine used for weighing the corn is the ordinary

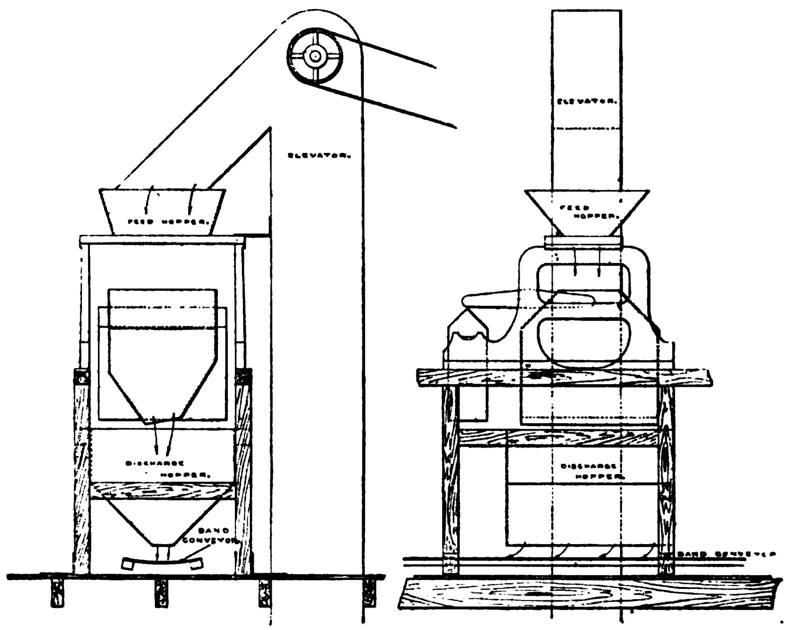


Fig. 413. Avery Weighing Machine for Grain.

type of weigher as already described, and is so connected with the chaff scale that they discharge together.

Above this chaff scale is a stirring device which ensures an even flow of the material from the hopper to the scale. This hopper is connected by spout with the chaff-cutting machine. Just below the chaff hopper is a small pulley driven by a belt, which is attached by a spindle to the valves in such a way as to automatically aid in lifting them when required by the machine. Both machines simultaneously discharge into the large hopper below, and right on to the mixer, which consists of a rapidly revolving spindle studded with spikes and driven by a belt as shown. This is to prevent the corn, owing to its greater weight, from falling into the sack quicker than the chaff. The inside of the hopper is fitted with a row of baffle plates which can be so adjusted that the corn discharges into the mixer in a more uniform stream than would otherwise be the case. From this mixer the provender falls into a breeches piece and thence into either sack as required. These machines are best fitted with glass-panelled covers, which not only obviate any escape of dust, but also prevent any tampering with the mechanism.

The "Simplex" Grain Scale.—This machine was built by Messrs H. Pooley & Son Ltd., Birmingham, and is illustrated in front elevation and side view, Fig. 415. Its mechanism is simple, the working parts are few, and there is not much that is likely to get out of order. A machine weighing 100 lbs. at a charge will make about three weighings per minute. It will be seen from the drawing that there is a solid iron ball weight A. In a machine taking charges of 100 lbs., this ball will weigh 50 lbs., the same as the weight B underneath. The receiving hopper is on the opposite side of the weigh-beam, and when it has received its 100 lbs. of wheat from the feed hopper C, it tilts up the runners on which the ball A rests, and at the instant the ball moves towards the hopper on its runners it comes in contact with a semicircular lever D, which cuts off the supply, while by the time it has reached the hopper it touches another lever D^1, which releases the discharge gate E at the bottom of the hopper and allows the grain

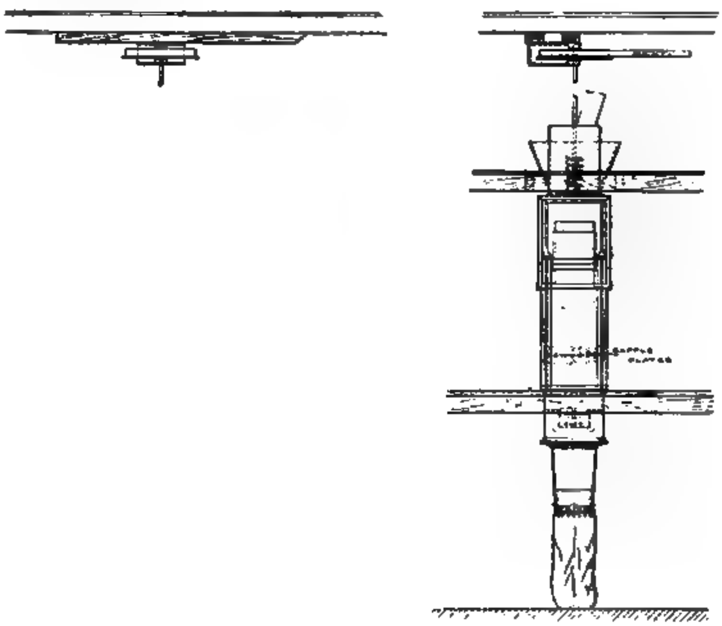


Fig. 414. Avery Weighers for Chaff and Grain.

to escape. As soon as the skip is empty the runners of the weight tilt up again and the ball begins its return journey. Immediately the ball commences to move in the opposite direction the recipient closes again through the release of the lever D^1, and as soon as the ball reaches the terminus it turns the feed on by means of the first-mentioned lever D.

There is no time wasted between the weighings, but the most remarkable point about the machine is this, that it works altogether noiselessly, there being no clicking and engaging of levers in catches as is the case with many other weighing machines. The discharge door E is practically locked during the drop of the skip, and as there is no connection between the feed gate and the skip, there should be no danger of the discharge gate getting blocked, as the feed gate cannot open during the discharge on account of the heavy ball not being able to return and open the gate until the grain in the hopper has been removed.

The "Simplex" weighing machine is built in six sizes, the respective machines being for charges weighing from 20 to 100 lbs., and the machine occupies a height of only 18 inches to 2 feet.

Ingrey's Automatic Coal-weighing Machine.—The hopper weighing machines which have already been described for automatic weighing of coal and other minerals cannot attain absolute accuracy when dealing with material of an uneven size, on account of the principle generally adopted of weighing the material in charges of precisely the same weight.

Machines of this type deal accurately with granular material such as grain, seeds, or dry small coal, but in dealing with large coal, &c., their work is obviously less accurate on account of the uneven nature of the material being handled. It is hopeless to expect anything like absolute exactitude in dealing with large coal, as a lump could not be

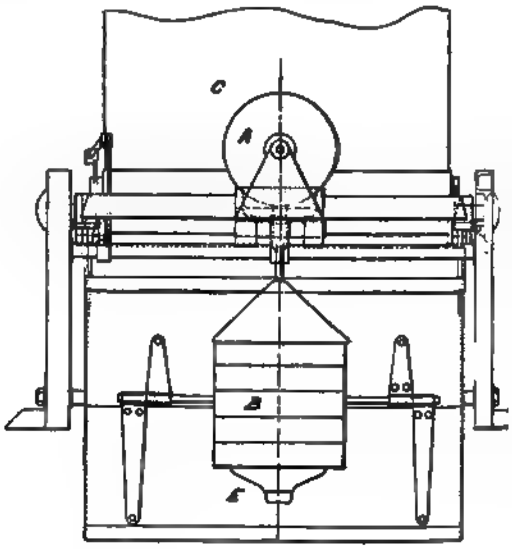


Fig. 415. "Simplex" Grain Scale.

divided to make up the correct weight. In cases of Welsh coal particularly (where the pieces are of abnormal size) the difficulty would be insuperable.

Ingrey's weighing machines have been designed on a different principle, so as to give more accurate results with coal or minerals of the most uneven size and containing the largest lumps. They are provided with a bucket of sufficient capacity to deal with the maximum quantity of coal to be fed into it at one charge. This bucket is in some cases fitted with delivery doors at the bottom, in other cases at the side. In the latter case the bottom of the bucket is sloped at an angle of not less than 40 degrees, as small coal will not discharge freely at a more obtuse angle. This recipient is provided with trunnions which normally rest on steel plates or girders, the whole force of the blow from the coal being received by them. These girders are hinged at one end and provided at the other with rollers. The rollers rest on cams, the partial revolution of which allows the ends of the girders to descend until the latter are free from the trunnions. The bucket is then deposited on the knife edges of the weigh beam. The weigh beam is supported on knife-edged centres, and connected by links and further knife edges to

compound levers and a weigh rod. The latter carries a balance weight so adjusted as to give perfect balance to the recipient when empty. Any quantity can be dealt with (up to the capacity of the bucket), as the larger or smaller loads will give a greater or lesser pull to the weigh rod, of which the movement is registered by a recorder. The various parts have been made of sufficient strength to resist the action of heavy and lumpy Welsh coal, which is delivered on to the machine in charges of about 2 tons.

When the coal has been deposited in the recipient, and the cams are put in operation,

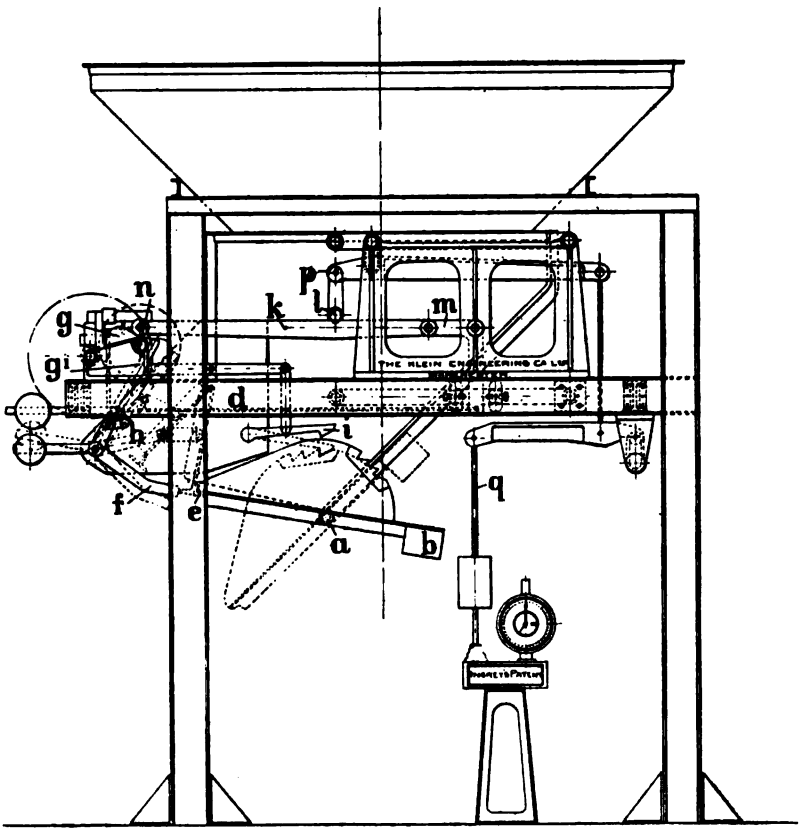


Fig. 416. Showing Ingrey's System of Delivery Doors.

the lowering of the girders allows the bucket to gently descend so that the coal may be considered to weigh itself.

The power required to operate the machine is trifling, and can be supplied by electricity, hydraulic, or any other power.

When dealing with large material such as Welsh coal it is important to have an ample outlet to the weigh bucket. Delivery doors such as are illustrated in Fig. 416 would seem to meet all requirements; this illustration shows a fixed machine capable of dealing with 2-ton loads.

It will be seen that the lower door is pivoted at *a*, and is provided with an overbalance *b*, so that when free it will always close itself. The upper door is hinged at *d* and terminates with a flange or plate *e* which acts as a shelf upon which the edge of the lower door normally rests.

When the doors are closed they are retained by door stops *f* so that they cannot fly open when the load is received. After the weighing has been accomplished a cam or pin *g* engages with a tailpiece g^1 connected with the stops and depresses the latter so that the doors are free to fly open by the pressure of the material. A second cam engages with the lever *h* and raises the top door to the position shown by dotted lines, whilst the lower door falls and forms a continuation of the sloping bottom of the weigh bucket, and is retained in its open position by catch hooks *i*. When the whole of the load has been delivered these hooks are raised and the balance weight *b* causes the door to close, whereupon the top door is released by the cam and closes with its flange beneath the edge of the bottom door as shown. But little driving power is required, as the opening operation is performed by the force of the material being handled, and a very large opening is given for its delivery.

The weigh bucket is normally supported by girders or plates *k* which engage with

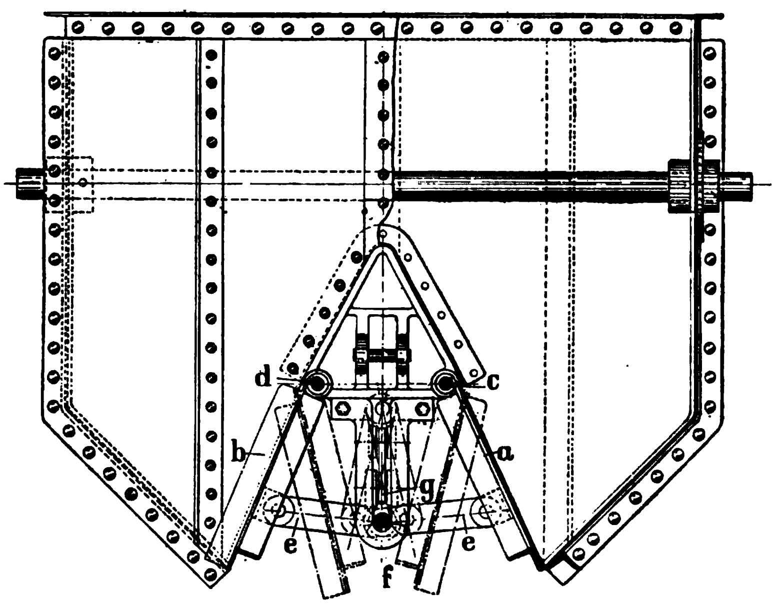


Fig. 417. Arrangement of Ingrey's System of Delivery Doors.

the trunnions *l*. These girders are pivoted to a bell crank *m*, the tail end of which is held in its vertical position by a weight or spring when the load is shot into the bucket. The weight or impact causes the bell crank to take a slight movement, which is utilised to throw a clutch into gear and to set the cam shaft *n* in motion. This shaft makes one complete revolution and then automatically throws itself out of gear. The first part of the revolution lowers the girders *k* free of the trunnions and gently deposits the weigh bucket on to the knife edges *p* of the weigh beams, and the weight of the load is transmitted through the weigh rod *q* to the recorder. The cams continuing to revolve, raise the girders, and when the knife edges are freed the doors are operated and the weighed material discharged, the final action being to close the doors, whereupon the cam shaft ceases to revolve and the machine is ready for the succeeding load. The time occupied by the processes of receiving, weighing, recording, discharging, and restoring is thirty to thirty-five seconds.

The recording apparatus is contained in an air-tight casing, and to prevent the entry of dust the weigh rod is provided with an oiled silk diaphragm which offers no resistance to its movement.

The outer dial is marked to 10 cwt., 1 ton, or 2 tons as the case may be, and each hundredweight is subdivided in ½ cwts., quarters, 14 lbs., 7 lbs., and 3½ lbs. When the load is being weighed a hand indicates the exact weight, and when the girders are raised and the bucket freed from the knife edges, the hand returns to zero, and in doing so operates the hand of a smaller dial which is divided into tons. This hand does not

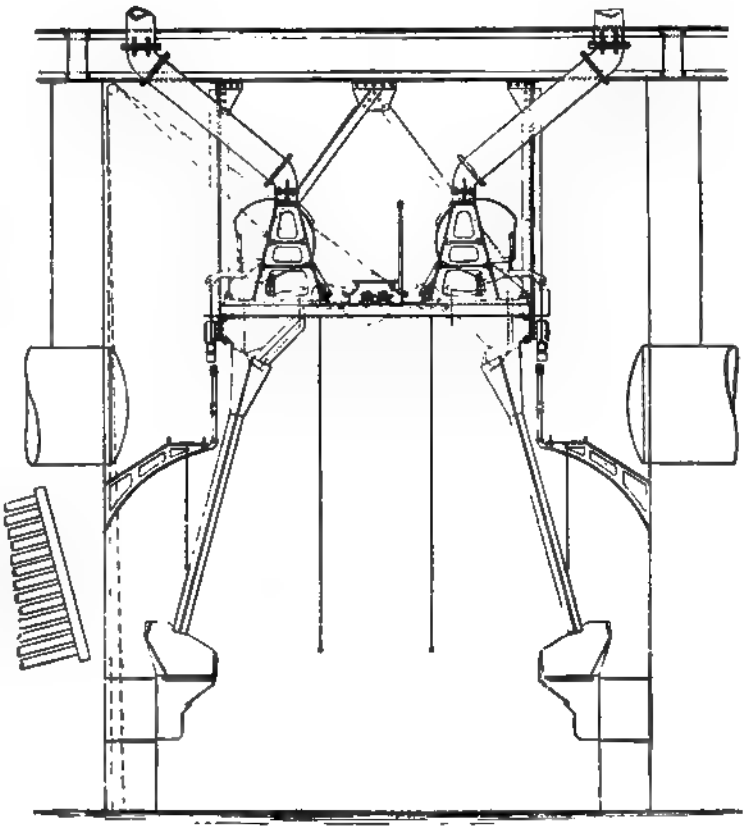


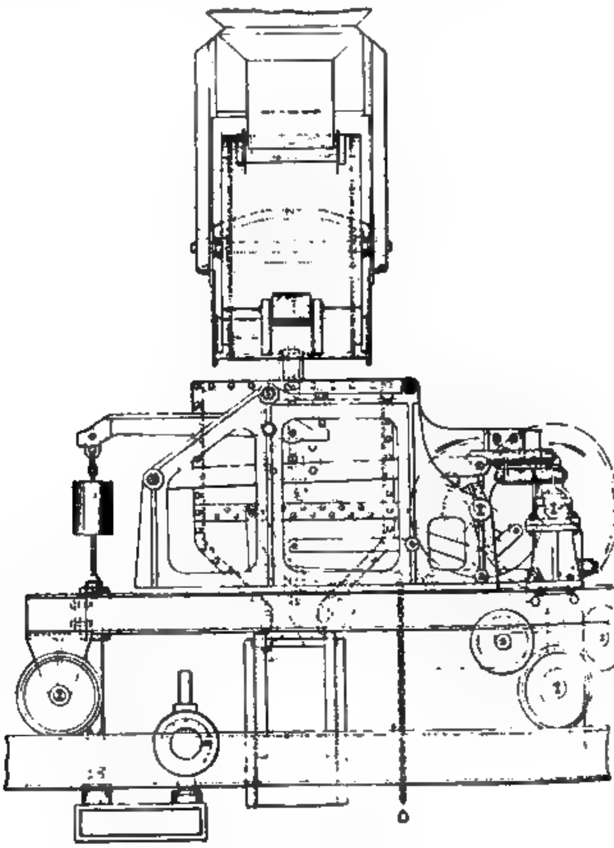
Fig. 416. Ingrey's Weighing Machine for Feeding Stoker Hoppers, at Work at the Stuart Street Electric Station of the Manchester Corporation Tramways.

return to zero, but advances with each operation, adding on to its previous indication the amount shown by the larger hand. When the small hand has reached the 20 cwt. point, the unit figure of the counter is moved one, there being five figures to this counter. The total reading can be 99,999 tons, plus whatever may be indicated on the smaller dial.

When small or moderately sized material is being weighed, delivery doors of another form are sometimes used. These doors have the advantage of dispensing with all door stops or catches, and of always retaining their closed position, no matter what the shock of the incoming load may be.

Fig. 417 shows the arrangement. The weigh bucket is formed as shown, and is

provided with two doors *a* and *b*, which are hinged at *cd*. The two doors are connected by toggles *e* which are united by a rod or spindle *f*, the ends of which enter a slot *g*. This spindle can be raised by the action of a cam and levers. It will be seen that when the toggles are dropped to their lowest position they pass the straight line, so that any pressure upon the insides of the doors would tend to force them further down if the slot would allow. When they are raised above the straight line the pressure will cause them to open to the position shown in dotted lines, and the material will be discharged. The doors are retained in their open position a sufficient time to ensure complete delivery.



Figs. 419 and 420. Two Views of Ingrey's Weighing Machine as used in connection with Boiler-houses, at Work at the Brimsdown Station of the Metropolitan Tramways Co.

Modifications of this machine are used for supplying mechanically stoked boilers, one of which is illustrated in Fig. 418. A slowly revolving shaft extends the length of the boiler-house, and can give motion to a cam shaft on each machine when a clutch has been thrown into gear by pulling a cord or chain.

The first operation is to move a pivoted measuring drum into a position which will close the opening at the top and deliver the contents into the weigh bucket (about 4 to 5 cwt. at a time). The drum is then restored to its normal position and fills itself again ready for future use. The bucket is then lowered on to the knife edges and its load recorded in the manner already described. On the bucket being restored to its rigid

condition, the weighed coal is delivered to the stoker hopper. In some cases these machines are made to run upon rails so that one can be used to serve several boilers. Figs. 419 and 420 show such a machine in two views erected at the Brimsdown Station of the Metropolitan Tramways Co.

The automatic weighing of coal at the pit's mouth can also be effected by the Ingrey weighing machine, as shown in Fig. 421, which is capable of dealing with the whole output of the colliery. One of these machines is at work at the Sherburn Hill Colliery, Durham.

The coal is brought up in tubs, each containing about 8 cwt., the speed at which they are dealt with being at the rate of four to five per minute, which equals about 2 tons. It will be seen from the illustration that the tubs are run into a tippler which

Fig. 421. Ingrey's Automatic Weighing Machine, at Work at the Sherburn Hill Colliery, Durham.

by a revolving motion deposits its contents in a weigh bucket. This operation of tippling occupies $3\frac{1}{2}$ seconds, and during the remaining $8\frac{1}{2}$ seconds the coal is weighed, and its weight recorded by the indicator. The doors are kept open for a sufficient time to give complete delivery; they are then automatically closed and locked, whereupon the machine is restored ready to receive the next load.

A number of machines on this system have been erected upon a floating pontoon on the Lower Thames, the pontoon being fitted with nine hydraulic cranes to feed the weighers. These machines are also built portable with a capacity of weighing up to 2-ton loads, and are employed in connection with the unloading of large coal ships. They are said to deal with some 30,000 tons per week, a considerable proportion being large Welsh coal.

Avery's Automatic Scale for Weighing Coal, Coke, Minerals, and Similar Materials.—This weighing machine is very similar to the one for grain already described, and the chief modifications concern the feeding device.

Fig. 422 shows this appliance in two views.

With regard to the run of the material, to ensure an even and continuous flow an agitator has been fitted into the hopper R. This apparatus is provided with a clutch gear W, by which the pulley can be thrown in and out of gear. The feed hopper is generally provided with an opening X, which affords free access to the feed. The machine itself, in addition to the one valve, is furnished with a second valve T, which is connected with the main valve by a link T^2, so that when the latter is raised by the pendant in the ordinary way the second valve is also lifted, and is held open in that position by the catch T^1, remaining thus open while the main valve closes after the first operation. The "dribble" now takes place along the whole length of the valve, and this can be regulated by a plate T^3.

As soon as the weighing is completed, the levers H^1 and H^2 come down as before, and push aside the catch T^1, thus allowing the second valve to shut, and so completely cut off the supply. The remainder of the process is identical with that of the ordinary weighing machine already described.

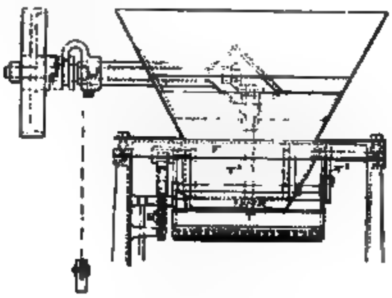


Fig. 422. Avery's Automatic Scale for Coal, &c.

Figs. 423 and 424 show two of these machines and their accessories.

One of these weighers is at work in the boiler-house of the Glasgow Corporation Electricity Department. By means of this machine the mechanical stokers are automatically fed with coal from the bunkers above, and a record is kept of the total consumption of fuel. The machine is supported on brackets bolted to the girders, and has a feed hopper above which is connected by spout with the coal bunker. An agitator, as already described, is placed in this hopper, and in the particular case illustrated one rope drives the set of five agitators in five weighing machines.

As the coal passes through the scale its weight is duly recorded. It then falls into the discharging hopper below, and thence into the two spouts which feed the stoker hoppers.

Charge after charge is weighed and delivered to the stoker hoppers until the spouts leading to them are quite full, whereupon the weighing machine stops automatically. As soon, however, as sufficient coal has been used by the stokers to clear the shoot, the weighing machine will recommence work, and in this way always adapts itself to the consumption of coal.

Instead of fixing a machine beneath each coal bunker, another method is to have one large machine fitted on a travelling frame which runs on rails overhead and can

be brought under each bunker as required. This system has the advantage of keeping the machine at work even when one or more boilers are shut down.

By a simple mechanical contrivance the same rope which drives the agitator can be used to move the travelling frame of the weigher. A handle, easily accessible from the firing floor, controls the movements of the weighing machine in either direction. It is sometimes fitted with a swivel spout as shown, which will enable it to feed the boilers on either side of the house. A valve controlled by hand locks the bottom of the spout until the machine is in a position opposite the stoker and ready to discharge.

B. Continuous Weighing Machines.

The Continuous Weigher (Blake Denison's).—This machine is so constructed that it will weigh the material in the course of being conveyed. Thus a section

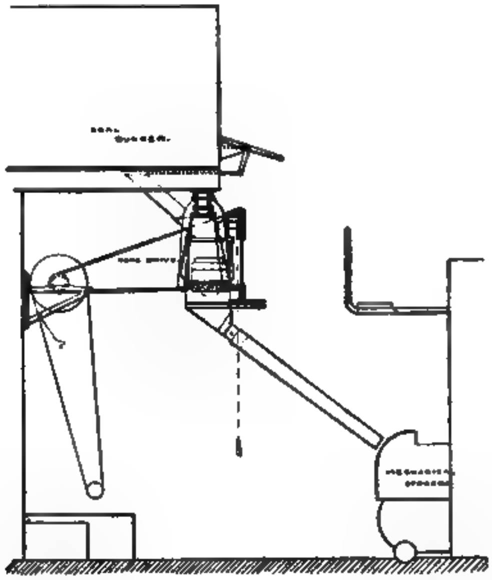


Fig. 423. Method of Employing Avery's Scales in a Boiler-house of the Glasgow Corporation Electricity Department.

of the conveyor is also a portion of the weighing machine. The principle upon which it is constructed is that of weighing the contents of a given length of conveyor at intervals of time corresponding with the travel of such length, and automatically recording such weight. Thus, if the machine is made to weigh 6 feet of conveyor at a time, it will weigh and record every time 6 feet has passed, and so every section will be weighed consecutively.

The special features of the weigher are—

1. A steelyard balanced to suit the unloaded conveyor and arranged to rise accurately in proportion to the load.
2. A gripping device to hold the steelyard fast at suitable intervals.
3. A measuring gauge or quadrant to ascertain the weight indicated by the steelyard when so held.
4. A recording mechanism to show the result.

The section of the conveyor to be weighed is supported on a roller or other suitable device which is suspended from the vertical rod of an ordinary multiple lever platform weighing machine.

To balance the load upon the conveyor as it passes over the roller, a mercurial dash-pot is used, the hollow piston of which is suspended from a fixed point on the lever in place of the usual sliding weights on a graduated lever (see Fig. 425).

The dash-pot consists of a carefully turned vertical piston, its lower part dipping into a bath of mercury, and loaded sufficiently to cause it to be submerged some distance in the mercury before the machine is in balance unloaded. It will be seen that when the heavier load comes on the machine the lever rises, and the greater portion of the piston comes out of the mercury until the balance is again established. At the same time a small hole in the hollow piston allows the mercury to escape comparatively slowly. This arrangement acts as a dash-pot for steadying the oscillations of the lever when the

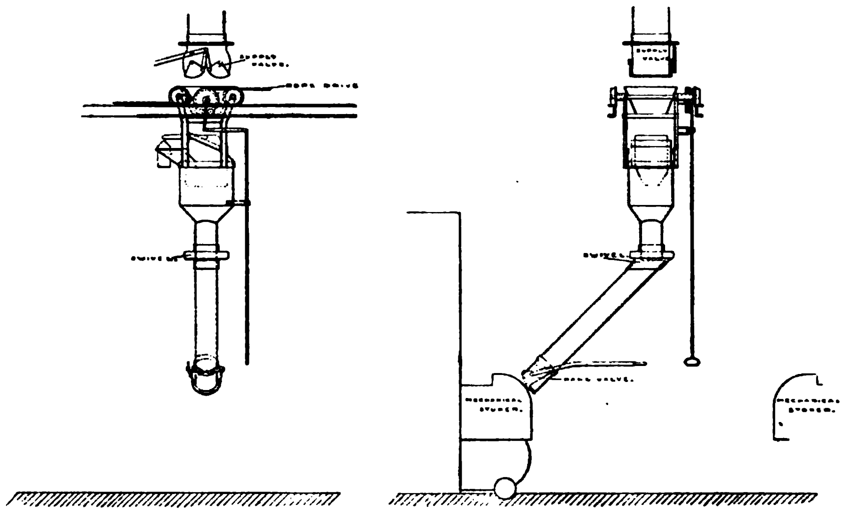


Fig. 424. Avery's Portable Weighing Machine, as used at the Boiler-house of the Sheffield Corporation Electricity Department.

latter takes up a particular position due to the weight of the length of conveyor and the load on it.

The registering mechanism is shown in Fig. 426. A cam A causes the lever E to move to the right, and thus thrusts the steelyard F of the weighing machine against a surface so roughened as to prevent it from slipping. Another cam then permits the registering quadrant (which is moved to the right by a system of levers actuated by gravity) to move freely to the right, a movement which is only checked by the clamped steelyard F.

As the quadrant moves to the right the ten pawls ride over the teeth of the registering wheel.

There is a brake on the registering wheel which acts immediately the quadrant is at its left-hand limit. This is to prevent the momentum of the wheel from carrying it on.

The cam G causes the quadrant invariably to move back to the same left-hand limit, the pawls engaging and carrying the registering wheel with the quadrant.

It is therefore evident that the rotation of the registering wheel is dependent upon the extent of the movement of the quadrant to the right. This is determined by the position of the weighing lever, and this again by the weight on the machine. The two cams A and G are on one shaft, and this is driven by bevel wheels from one of the conveyor terminals.

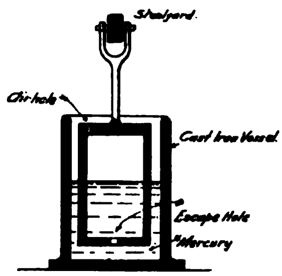


Fig. 425. Dash-pot.

Each of the ten pawls is one-tenth of the pitch of the teeth of the ratchet wheel in advance of the next to its left. The maximum slip is therefore one-tenth of a tooth. In the machines already built the cycle occurs every five seconds, and is as follows :—The steelyard is free for about three seconds, during which time it assumes the position proportional to the load upon that section of the conveyor which is supported by the weighing machine. It is then gripped by the action of the first cam, the second cam immediately allowing the measuring quadrant to move forward until it touches the steelyard, where it remains until pushed back by the further motion of its cam; the first cam then releases the steelyard. The weight is recorded by the backward motion of the measuring gauge. There are thus four motions—gripping, measuring, recording,

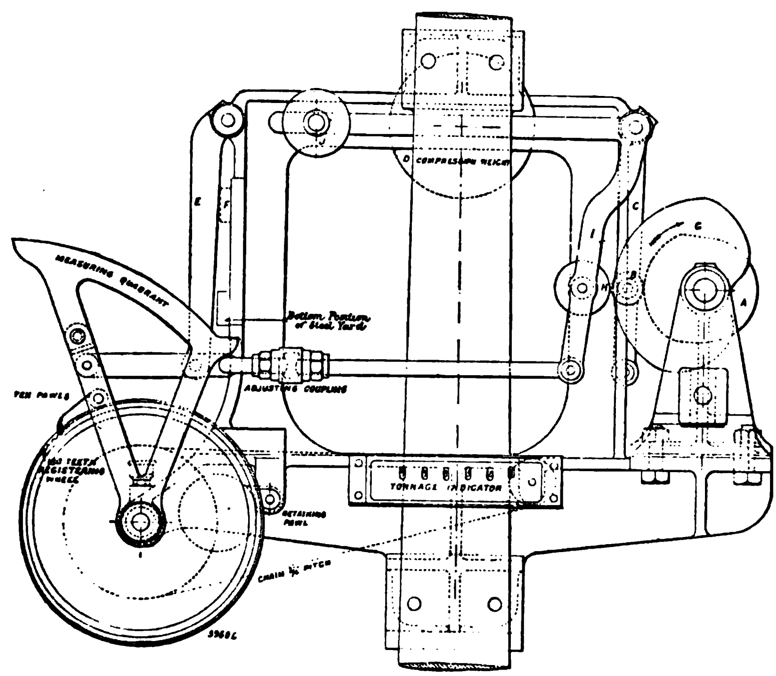


Fig. 426. Diagram showing Cam and Quadrant Arrangements as used with Blake Denison's Weighing Machine.

and releasing—which occupy somewhat less than half the time of the whole cycle. It will be readily understood that when the steelyard is at its lowest position it must touch the measuring gauge at its stationary position, as there can be no motion of the latter if the steelyard indicates no load. It has, however, proved impracticable to allow the steel yard to touch the gauge at the lowest position, for two reasons :—

Firstly, it is difficult to adjust the steelyard so accurately that it touches the gauge and yet exercises no pressure upon it.

Secondly, the vibration of the conveyor gearing, &c., sets up oscillations in the steelyard which would allow the gauge to occasionally gather a few pounds and so introduce an error. This difficulty has been overcome by balancing the steelyard at a point somewhere above zero, and then subtracting a corresponding amount of weight each time a weighing takes place.

Thus, for instance, if the steelyard is so balanced as to remain in a position corresponding to ½ cwt., when there is no load on the conveyor, the measuring gauge will register on its return stroke ½ cwt. each time. But if a device is introduced of deducting ½ cwt. from the register each time, the motions cancel each other, and the register remains unaltered. The device referred to consists of a set of wheels, two of which gear with a pinion carried upon an arm of the wheel driving the counter (see Fig. 427).

It will be seen at once that if the two bevel wheels move an equal amount but in opposite directions, the result will be that the pinion is merely revolving upon its axis. But if one of the wheels moves more than the other, the pinion will be driven forward or backward accordingly, and will carry the registering wheel with it. To the spindle of one of these bevel wheels is attached a ratchet wheel having a suitable number of teeth—where the lever is balanced at ½ cwt. the number would be forty—while a lever and pawl operated from the cam shaft drives the ratchet wheel one tooth every cycle, deducting a corresponding amount from the register. The other bevel wheel is driven from the measuring gauge.

Fig. 427. Registering Device as used with Blake Denison's Weighing Machine.

The counter or register thus operated records the quantity of material passed over the conveyor during a given period. The measuring gauge or quadrant consists of a vulcanite plate securely fastened to a light steel frame. The frame encloses a finely divided steel ratchet wheel, and carries a set of ten pawls of different lengths engaging the said wheel. This confines, as has already been remarked, the error due to loss of motion between the pawls and the wheel to one-tenth of a tooth. There is also a set of ten retaining pawls attached to a fixed stud on the body of the machine. The large steel ratchet wheel is keyed upon a spindle connected with the registering counter, while the frame carrying the pawls swings freely upon the boss of the wheels. This frame has a reciprocating motion imparted to it by means of the cam previously described. This machine is built by Messrs Samuel Denison & Son, Leeds.

C. Intermittent Weighing Machines.

Avery's Automatic Weighbridge.—This machine is intended for weighing trains in motion. Platform, 15 feet 8 inches by 6 feet 2½ inches; rails, 4 feet 8½ inches gauge.

This weighbridge is constructed entirely of iron, and is designed by Messrs Avery. It consists of one of their improved three-lever type scales, which allow the platform to swing in the direction in which the traffic moves, thus minimising the wear on the knife edges. It is for loads of 20 tons, with the usual margin for safety. The essential features of this weighbridge are the weighing of a moving load passing over the platform,

with a simultaneous indication of the weight of the load.

This result is attained by cutting away a portion of the permanent way at each end of the weighing platform, and substituting short lengths of rail which rest at one end on pedestals upon the permanent way, and on the other upon the girders of the weighbridge.

It is claimed for this arrangement that it has the merit of gradually transmitting the load to the levers of the weighbridge, and thus giving a steady movement to the indicating mechanism, enabling the finger of the dial to settle more quickly than would obviously be the case if the maximum load were suddenly transferred to the platform of the weighbridge, as is ordinarily the case.

This dial-indicating mechanism is of an improved type, being specially designed and constructed to protect the machine from an excess of friction and the accumulation of dust and rust, and also to preserve the sensitiveness of the scale. It entirely dispenses with springs, which is certainly an advantage.

Messrs Avery claim that by the combination of their "patent lead on rails" with their improved dial-indicating mechanism, trains of trucks running 2 to 3 miles an hour may be weighed. The frames which surround the weighing platform are of cast iron of strong section and 24 inches deep all round, with broad flanges top and bottom, and strong brackets at each end for carrying the rockers from which the main levers are suspended.

All the joints are accurately machined and bolted together, being absolutely true, and so preventing the possibility of any slipping under stress with variation in weighing.

The platform is of cast iron of strong section, the upper surface being roughened in the usual way. The girders and levers are also of cast iron, the levers being fitted with knife edges of hardened steel. Fig. 428 shows this machine.

Fig. 428. Avery's Automatic Weighbridge.

Avery's Colliery Tub Weighing Machine.—This machine is intended for weighing ore, &c., in tubs constructed to automatically register the number of loads, and total up the nett weight of the same.

Fig. 429. Avery's Colliery Tub Weighing Machine.

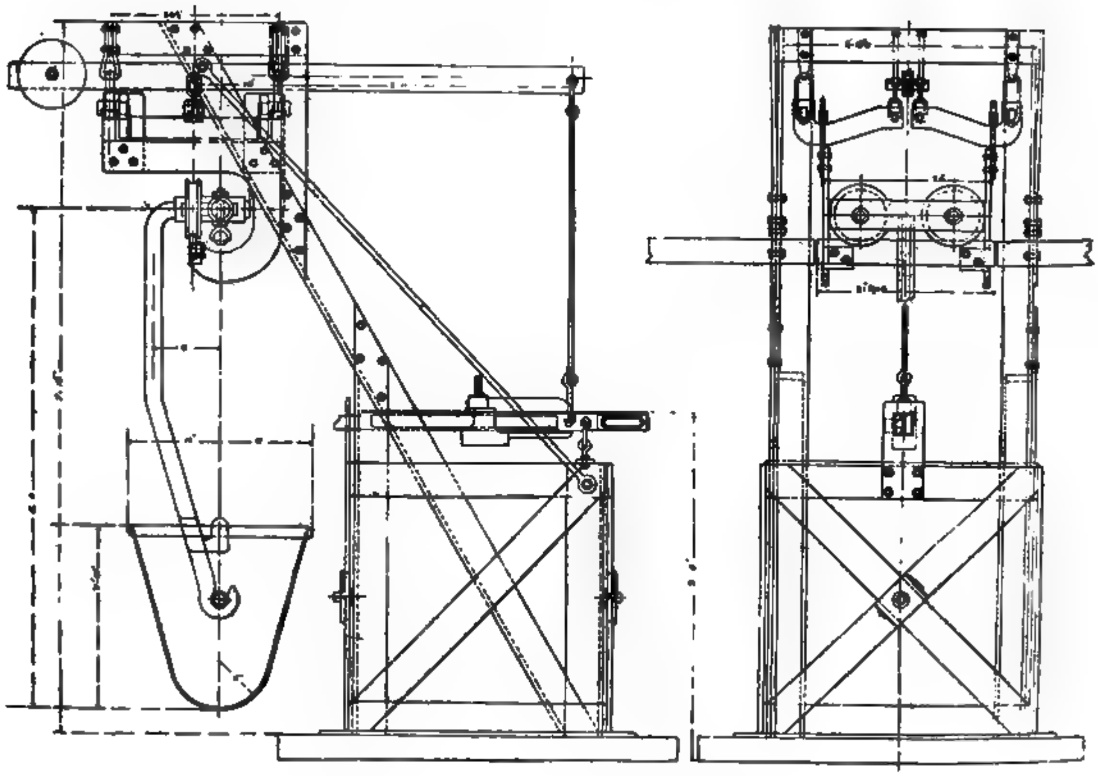


Fig. 430. Avery's Aerial Weighing Machine.

Fig. 429 gives an illustration of this machine. It has a capacity of 2,500 lbs., including 700 lbs. tare. It is self-contained, and is entirely constructed of iron, with a platform arranged to suit the length of the truck, and fitted with steel rails to a gauge of say 18 inches. Movable stops are affixed to the rails to prevent the tubs being moved on or off the machine, the use of which is explained later.

The pillar mechanism is enclosed in a dust-proof wrought-iron case, fitted with doors

Fig. 431. An Automatically Recording Weighing Machine.

secured with locks and keys, so that some person in authority may obtain a record of the weighings at any desired time, and have access to the mechanism as often as is necessary. Attached to the side of the pillar is a wrought-iron hand lever for actuating the movable stops on the rails. Inside the pillar is fitted an automatic self-registering mechanism which will record the total nett weighings during twenty-four hours or any other given time, up to 1,000,000 lbs., by divisions of 25 lbs., the nett weight of each

load not exceeding 1,800 lbs. A counter is also attached to the inside of the pillar to automatically record the number of trucks passed over the machine.

The method of using is as follows: Assuming that the machine is empty, and that the truck coming towards it is in the direction of the arrow, the stops AA being open, will allow the truck to come on to the platform until it reaches and is blocked by the stops BB. Before the next truck can come on to the machine the hand lever must be pushed back, when the operation described above may be repeated.

By the mere manipulation of lever C, the attendants can keep an accurate record of the total number of weighings, which is of course a register of the number of trucks passed over the machine as well as an account of the nett weight of each.

All the tubs would of course have to be adjusted to a given tare, so that the weighings would be registered as the absolute nett weight of the material in the trucks passing over the machine. Should the total weight be likely to exceed 1,000,000 lbs. in the given period, the mechanism could be adapted to register 10,000,000 lbs. or more if required.

Fig. 432. Perspective View of Timewell's Sack Filling and Sewing Machine.

Avery's Aerial Weighing Machine.—This machine is self-contained, and is built of wrought iron. Its action, as will be seen, is extremely simple.

A short detached portion of the rail on which the skip or bucket travels is suspended from the main levers of the apparatus, which at their fixed ends are hung from the framework, and are attached at their other ends to a single transfer lever, which is in its turn connected by rods to the steelyard.

A poise may be attached to the end of the steelyard for taring the weight of the skip or bucket. This machine is shown in Fig. 430.

Automatic Weighing Machine for Ropeway Skips.—A similar machine to that previously described, but for the purpose of weighing ropeway skips, is built by Pohlig, of Cologne, in conjunction with the Otto-Pohlig ropeway.

Fig. 431 gives a perspective view of such a machine.

Timewell's Patent Sack Filling, Weighing, Packing, and Sewing Machine.—In addition to the weighing machines which have already been described

Fig. 433. Timewell's Sack Filling and Sewing Machine.

for weighing and filling material into sacks, there is also on the market another ingenious type of machine which not only weighs the material and fills the sacks with it, but sews up the bags and delivers them ready for transport. This machine is known as Timewell's patent sack filling, weighing, packing, and sewing machine, and is built in a number of sizes for a variety of purposes. Sacks from 1 lb. up to a full-sized sack holding 2 cwts. or more, can be filled and sewn up by this machine.

Fig. 432 gives a perspective view of one of these machines. It is suitable for handling sacks up to 2 cwts., and with it one man and a boy are able to fill, sew up, and deliver ready for shipment or transport by rail, 60 to 180 bags per hour, according to the weight and nature of the material to be sacked. The fastening up of the bag by

sewing across the mouth a strong seam with thread gives the sack a more even appearance than those hand-tied, and the figures previously given show that the sewing process is much quicker than the tying process by hand. The machine occupies a floor space of 13 feet in length by 5 feet 4 inches in width, and can be driven by any existing driving power, or by an electro-motor. In the latter case it may be made portable, and can

Fig. 434. Timewell's Sack-filling Machine for Flour, Grain, &c.

therefore be used on the quay-side for taking grain from the granary and delivering the sacks containing the correct weight neatly sewn up ready for shipment. This machine is used for flour, grain of all kinds, coffee, cement, guano, sugar, &c. Beyond the obvious merits it possesses, it has the further advantage of packing more material into the bag than can be done by hand, so that it virtually reduces the size of the package. This is

effected by the sack being tapped whilst in a hanging position during the filling, conveying, and sewing operations. The filled bags, as they leave the machine, can be, if required, delivered to a conveyor or shoot, and thus conveyed to a road van or railway truck. This saves floor space as well as labour, the sack as soon as it is filled leaving the building and being disposed of elsewhere.

Fig. 433 shows a machine of this description, which, however, confines its operations to sewing, and is here shown in connection with one of Simon's sack-filling machines (as described on page 387), and with the two combined one attendant will sew bags up to 2 cwts. at the rate of one to two per minute according to size.

Fig. 434 illustrates a similar machine for filling smaller bags of flour, grain, yeast, baking powder, oatmeal, rice, coffee, &c. It is for bags of 1 to 14 lbs. in weight, and one boy can sew from five to fifteen bags per minute according to size. The top of the bag can either be sewn straight across, or pleated and sewn as seen in the illustration, thus making a neat package. The weighing hopper is shown on the top of the machine, and can be connected with the supply shoot. The platform upon which the bags are conveyed while on the machine may be raised or lowered, as on the previous machine, in order to suit the size of the sacks. The floor space occupied is 6 by 4 feet, and the power required to drive the machine is about ½ HP.

The hemming and pleating attachments are very complete, the hemmer folding over the top of the bag twice, and the pleater gathering up the top and thus giving the bag the customary tied appearance. Machines without this attachment make very neat packages, while folding and pleating are well suited to bags of small size. The machine can deal with bags of paper as well as of canvas and other textile material. Bags sewn with this machine can easily be opened, and there is no tedious unpicking of sewn thread, as, if the end be undone, the thread can be withdrawn in one piece.

These machines are built by the Sack-Filling and Sewing Machine Syndicate Ltd., London.

CHAPTER XXVI.

COALING OF RAILWAY ENGINES.

As far as Europe is concerned, automatic machinery has not been very much used for the coaling of locomotives. The old methods are still in wide use, baskets or other receptacles, holding about 1 cwt. of coal, being carried, often by hand, from the platform in the coal-yard to the tender of the engine. It is also quite usual to use small cranes worked by hand or by electricity for coaling locomotives, which is a most expensive way, but it is to be hoped that the efficient locomotive coaling installations on American lines will soon find favour with the all too conservative British railway companies. In order to pay, such installations would have to be on a scale of not less than a daily charging of 100 to 150 locomotives.

Coaling Railway Engines on the South-Eastern and Chatham Railway. —Some noteworthy improvements have been carried out at Slades Green by Mr S. Wainwright, chief mechanical engineer of the South-Eastern and Chatham Railway. For coaling the engines the coal stage is fitted with an ordinary elevator which, after having undergone several modifications, has been given an extended trial with considerable success. The elevator consists of twenty buckets, each capable of containing about ½ cwt. of coal loosely filled. These are secured to an endless chain which runs over two sprocket wheels, one mounted on the upper end of the frame under the roof of the stage, the other at the lower end in a pit some 7 feet below the floor of the coal stage, into which pit the coal is shovelled direct from the waggons on the inside road.

An electro-motor is placed on a bracket on the engine-house wall about 20 feet away; it makes about 500 revolutions per minute, and drives (by means of covered-in belting) a countershaft on the elevator frame, while a pinion on this shaft gears into a large spur wheel, which drives the top terminal, the latter making about 25 revolutions per minute. Working at this speed the buckets deliver coal down the shoot to the tender at the rate of about 1 ton per minute. To avoid jamming the buckets in the pit by an accumulation of coal, and so preventing the motor from starting, an automatic switch has been devised, which by the action of raising a slide and admitting coal into the pit, starts the motor before the slide is sufficiently raised to admit coal in any quantity, a water spray to lay the dust being simultaneously turned on. The coal is delivered close to the top of the tender, gear being provided to lift the shoot clear of the chimney and cab of the engine.*

Slades Green engine-shed, which contains sufficient accommodation for 100 engines, was built near Erith in 1899 to relieve and in some measure take the place of the chief London shed at Bricklayers' Arms. About 70 engines are stabled at Slades Green, and are chiefly employed in working suburban passenger trains between Charing Cross and stations on the North Kent, Mid Kent, and Greenwich lines. A few work main-line passenger trains, while the remainder are employed in working the heavy coal traffic from Messrs Cory & Son's coal wharves at Erith.

This appliance is shown in Fig. 435.

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* *Engineer*, 23rd May 1902.

Coaling Plant for the Railway Engines of the Philadelphia and Reading Railway, U.S.A.—This extensive installation is illustrated in Fig. 436. Four locomotives can be simultaneously coaled and supplied with water and sand. There are two "Hunt" conveyors, one for coal and one for conveying the ashes from the engine to the receptacle provided for them. Between the coal and ash hoppers is a small hopper for sand which is shown in the illustration. The capacity of this plant is 600 tons of coal per day and five loads of ashes. Nearly 500 main-line and suburban locomotives call at this station every twenty-four hours.

The staff employed consists of eleven men during the daytime and one man during the night. The labour is divided as follows:—One foreman, one stoker, one man in the

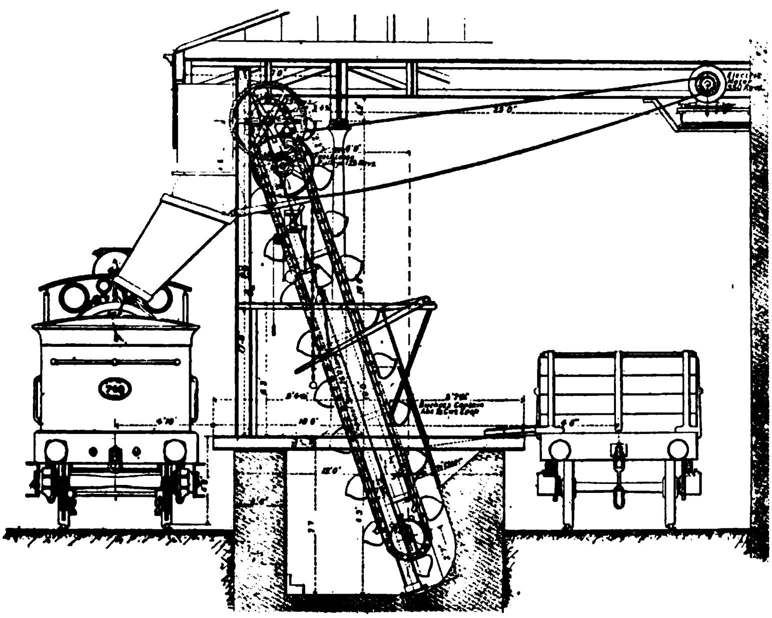

Fig. 435. Elevator for Coaling Railway Engines at Slades Green.

coal tunnel, one in the ash tunnel, one man above for wetting ashes, four men for filling the tenders, and one for filling the locomotive water tanks. During the night-time one man in attendance sees to the loading of the locomotives with coal.

Coaling Station of the Munich Central Railway.—This was erected by J. Pohlig, of Cologne, Hunt's patent conveyor being used. The whole installation consists of a steel structure, which supports, in addition to four large coal hoppers, the necessary conveying machinery. The plant has been erected over a tunnel, through which the lower strand of the Hunt conveyor runs. Above this tunnel is a large coal hopper built of masonry, over which run three lines of rails. The coal is brought to this large receptacle by self-emptying railway trucks, and can be withdrawn by a series of sixteen outlets on to the conveyor, which takes the coal to the top and delivers it to any one of the four hoppers, from which it can be withdrawn at a moment's notice to fill the locomotive tenders on each side of the structure.

Fig. 437 shows the whole of the installation in a longitudinal and cross section.

Fig. 436. Coaling Plant for Railway Engines on the Philadelphia and Reading Railway, U.S.A.

Coaling Station of the Boston and Albany Railway.—Fig. 438 shows a longitudinal section through this installation. The coal is received at the siding on the right. The "Hunt" conveyor, which passes from end to end of the building, receives the coal and deposits it in either of the two coal stores. From these stores the coal-pocket over the locomotive can be filled. This can also be supplied direct should there be room when coal is being received. The ashes are disposed of in a similar manner, as previously described, and collected in a separate bin, as shown in the drawing, whence they can be delivered to the truck in order to dispose of them.

Coaling Station for Railway Engines at Antwerp.—This is illustrated in Fig. 439. Conveying is done on the "Hunt" principle, the coal being deposited in the first instance by railway trucks, preferably self unloading ones, into a hopper beneath the level of the rails, while it is taken from there by a "Hunt" elevator into the elevated

Fig. 438. Coaling Station of the Boston and Albany Railway.

bunkers, which are fitted with measuring devices. From here the coal is lowered to the tenders of the engines (the length of the conveyor chain is 500 feet). The speed at which the conveyor runs is from 35 to 40 feet per minute, with a capacity of 30 tons per hour. The expenditure of power is 16 HP.

The hoppers into which the railway trucks are emptied are capable of holding 2,200 tons, whilst the elevated bunkers will together hold 100 tons. The measuring arrangements are such that coal of three different kinds may be fed to the tenders. The conveyor is at the same time used for the removal of the ashes from the engines, dumping them into a separate hopper to be taken up by the conveyor to a compartment of the overhead hoppers, whence they can be removed at any time.

Three men are employed to work the plant—one to look after the machinery and the electro-motor which drives it, one to stand by at the filling of the conveyor, and one to superintend the delivery of the coal, &c., to the engines. This installation was built by Pohlig, of Cologne, and was set to work in 1899.

430 Coaling Station for Railway Engines at Antwerp.

CHAPTER XXVII.

COAL-HANDLING PLANT FOR GAS-WORKS, POWER STATIONS, BOILER-HOUSES, ETC.

THIS is a most important branch of the mechanical handling of material, but so far, such installations have not come into general use, although through their use the saving in labour is so great that they very soon pay for themselves.

Coal-handling Plant of the Juniata Works, Altona, Pittsburg.*—This is illustrated in Figs. 440 and 441, and is probably one of the earliest installations of its

Fig. 440. Cross Section through Coal-handling Plant of the Juniata Works, Altona, Pittsburg.

class, the almost obsolete worm conveyor being here used for taking the coal from the railway trucks to the boiler-house.

This plant is designed to feed six boilers of 150 HP. each, simultaneously clearing away the ashes.

The plant absorbs 25 HP., and since its erection only two men have been required for the boilers. The coal is discharged from the railway trucks into a hopper over a

* The author is indebted to Professor Buhle, Technische Hülfsmittel, for the above description.

coal-breaker, in which it is reduced to the size of road metal, before being carried by a worm conveyor to one of the elevators (see accompanying illustrations).

The coal is then elevated to the top of the building, where it is deposited in a push-plate conveyor which delivers it to the hoppers over the boilers. The ashes and clinkers from the boilers slide down through suitable outlets on an underground push-plate conveyor and are conveyed to the opposite sides of the building, where they are carried by a second elevator into a special receptacle, whence they can be lowered at intervals into railway trucks. The hopper for ashes is shown in the cross section, as well as the mov-

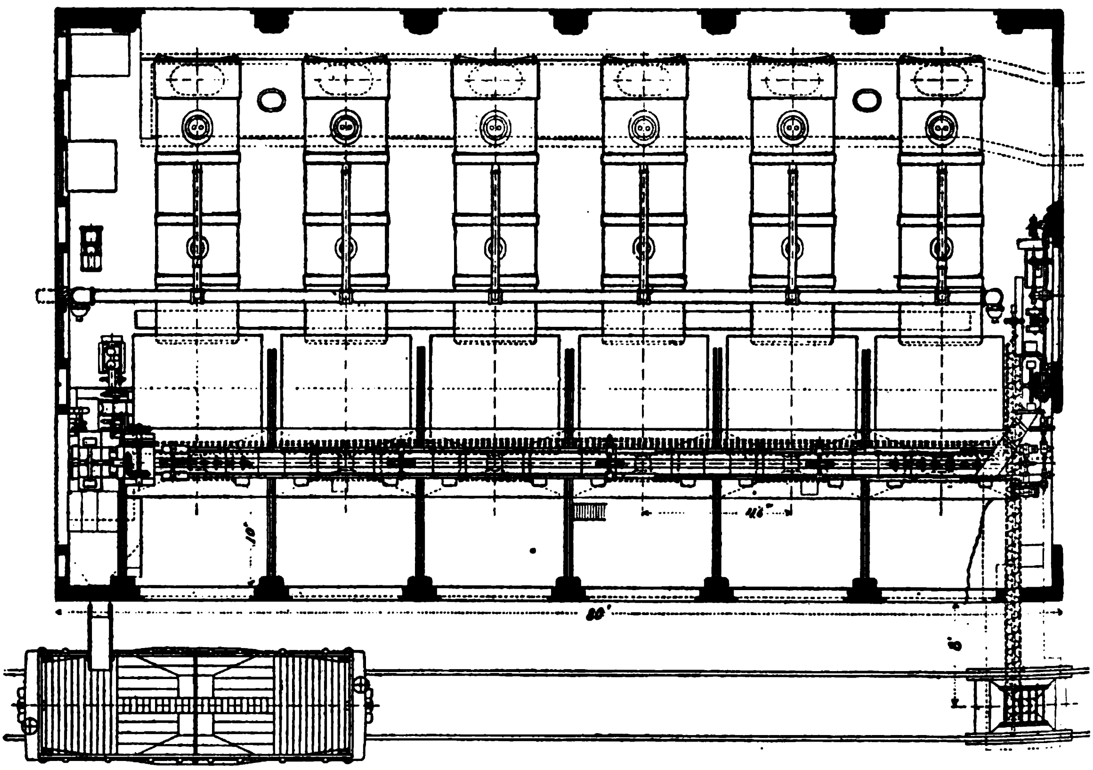

Fig. 441. Plan of Coal-handling Plant of the Juniata Works, Altona, Pittsburg.

able shoot which leads to the railway trucks. It will thus be seen that coal is received at one end of the building whilst the ashes are delivered to the railway trucks at the opposite end.

The description of this plant has been given because of its historic interest. In a modern plant, worm conveyors would not be used.

Coal-handling Plant of Messrs Arbuckle Brothers, Sugar Refiners, New York.—This compact installation of a coal store is shown in Fig. 442, and is designed on the "Hunt" principle. The ground floor of the building is used as a United States bonded warehouse. The boilers are placed on the two upper floors, whilst the coal store itself occupies the top floor and roof space. The building is erected at the water-side, so that the barges that bring the coal can lie alongside as shown in the illustration.

The coal is taken from the barges by means of a grab, by which it is delivered into the weighing machines. After weighing it is passed through a coal-breaker, which

Fig. 442. Coal-handling Plant of Messrs Arbuckle Brothers, New York.

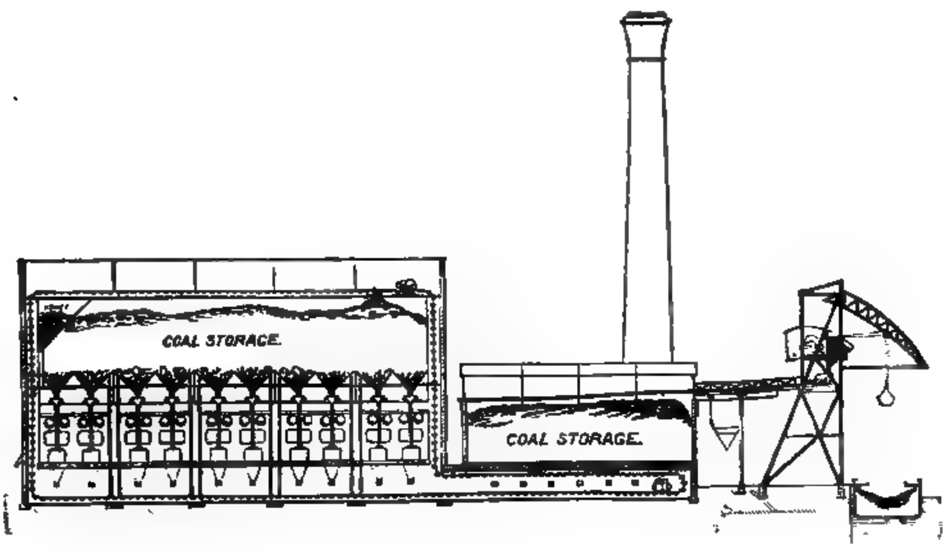

Fig. 443. Coal-handling Plant of the United Tramway Power Station, Dublin.

reduces it to a size not exceeding 2½ inches cube, and from the breaker the coal is deposited on the "Hunt" gravity bucket conveyor, which distributes it in the usual way over the coal store.

Coal-handling Plant for the United Tramway Power Station, Dublin.—This plant is illustrated in Fig. 443. The coal is received in much the same

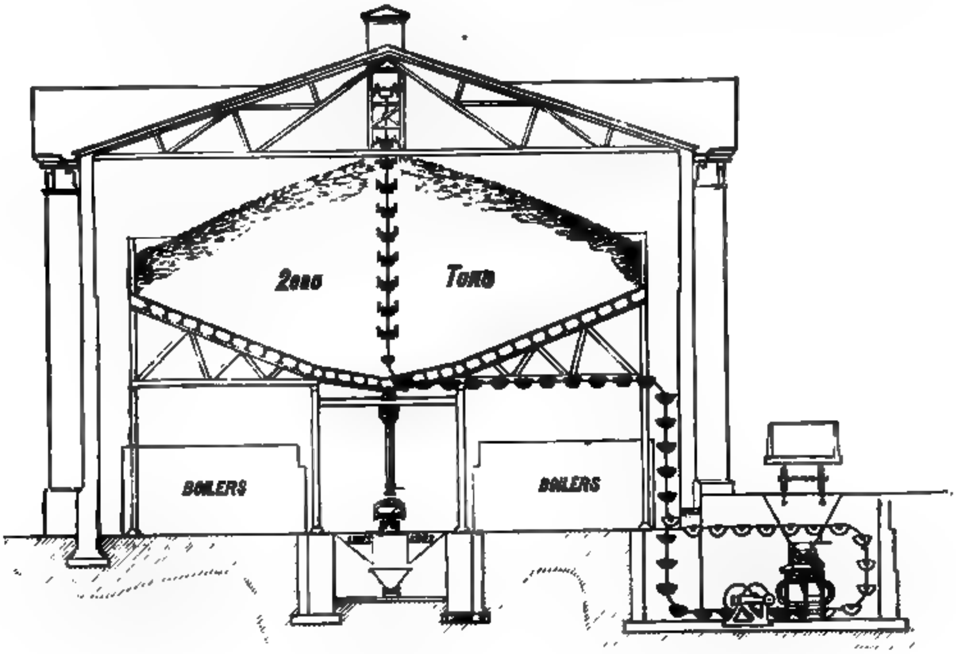

Fig 444. Coal-handling Plant of the Brooklyn Water-works.

Fig. 445. Coal-handling Plant, King's County Electric Light and Power Station, Brooklyn.

way as in the installation previously described, with the exception that there are two coal stores, the first of which is loaded by Hunt's automatic railway, while the coal

store over the boilers themselves is fed by an ordinary "Hunt" conveyor from the first-mentioned store. The ashes from the boilers are lifted by the same "Hunt" conveyor and deposited in a bin as shown. From this point the ashes can be disposed of by means of a spout.

The boilers are fed by automatic stokers, each of which is fitted with an automatic weighing machine to keep a record of the coal consumed.

Coal-handling Plant of the Brooklyn Waterworks.—Fig. 444 represents this plant, which includes a large coal hopper of 2,000 tons capacity built in the coal store above the boilers. The coal is brought to the spot by self-emptying railway trucks. The receiving hopper is connected with the coal-breaker, which reduces the coal to a size of 2½ inches cube before it enters the "Hunt" conveyor, which distributes it over the whole store. It will be seen from the illustration that although the conveyor runs the whole length of the store, the feeding end changes its direction and runs at right angles to the main length of the conveyor. The ashes from the boiler are removed by narrow gauge self-emptying railway trucks.

Coal-handling Plant of the King's County Electric Light and Power Station, Brooklyn, U.S.A. A longitudinal section of this installation is shown in Fig. 445. Here again the coal store is above the boilers. The coal is received by water and is hoisted from the barge to a height of 125 feet by the grab. It is then broken to about the size of road metal, after which operation it is weighed, then removed to the store by the "Hunt" automatic railway. There is an outlet from the coal bunker over each boiler.

Coal-handling Plant of the Brooklyn Heights Railroad Co.—Fig. 446 shows a longitudinal section through this coal-handling plant, which consists of a coal store, gantry, and boiler-house. It is installed at Fifty-seventh Street Station of the Brooklyn Heights Railroad Co. The coal store has a capacity of 8,000 tons. The coal is loaded in trucks and conveyed to the store by rope haulage. The distance from the store to the wharf is about 800 feet.

A "Hunt" conveyor takes the coal from the store across the gantry to the boiler-house proper. The tank shown below the gantry is a feed-water tank for the boilers.

Fig. 447 shows a further installation of the same

Fig. 446. Coal-handling Plant of the Brooklyn Heights Railroad Co.

railway company, but in this instance the top portion of the building is occupied by a large coal hopper, whilst the boilers beneath are arranged on two floors.

Fig. 448 shows a similar installation of the "Hunt" swinging conveyor as used at the Shepherd's Bush Station of the London Central Railway Co.

Swinging Conveyor for Feeding Boiler-houses.—Fig. 449 shows a boiler-house installation in which a patent swinging conveyor is used for bringing the coal

Fig. 447. Coaling Plant at Eastern Station, Brooklyn Heights Railroad Co.

to the boiler-house, whilst a similar conveyor is used in a tunnel underneath for conveying away the ashes. Very frequently this conveyor is used in conjunction with automatic stokers.

An interesting installation for feeding boiler-houses with small coal is shown in Fig. 450. The conveyor employed is the swinging conveyor, which receives its load from another conveyor of the same kind running at right angles to it at the far end. The conveyor is fixed above the bunkers, into which the coal falls through holes in the floor corresponding with outlets in the bottom of the conveyor.

This installation is in use at the Shipley Collieries, Derby.

Model Coal-handling Plant for Gas-works.—The model of an ideal installation for mechanically handling coal and coke in gas-works was exhibited by the Berlin

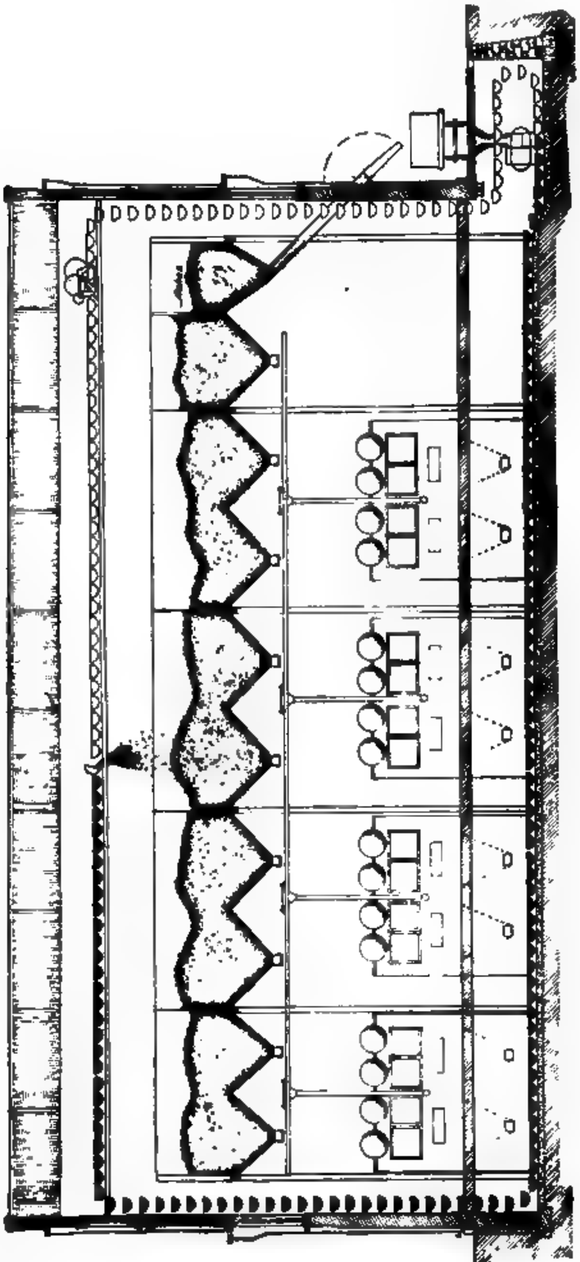

Fig. 448. "Hunt" Conveyor at the Shepherd's Bush Station, London Central Railway.

Fig. 449. Swinging Conveyor as used in Boiler-houses

Anhaltische Maschinenbau Aktien-Gesellschaft at the Paris Exhibition of 1900, and installations on similar lines have since been adopted in several gas-works.

Fig. 450. Swinging Conveyor for Feeding Boiler-houses, as used at Shipley Colliery, Derby.

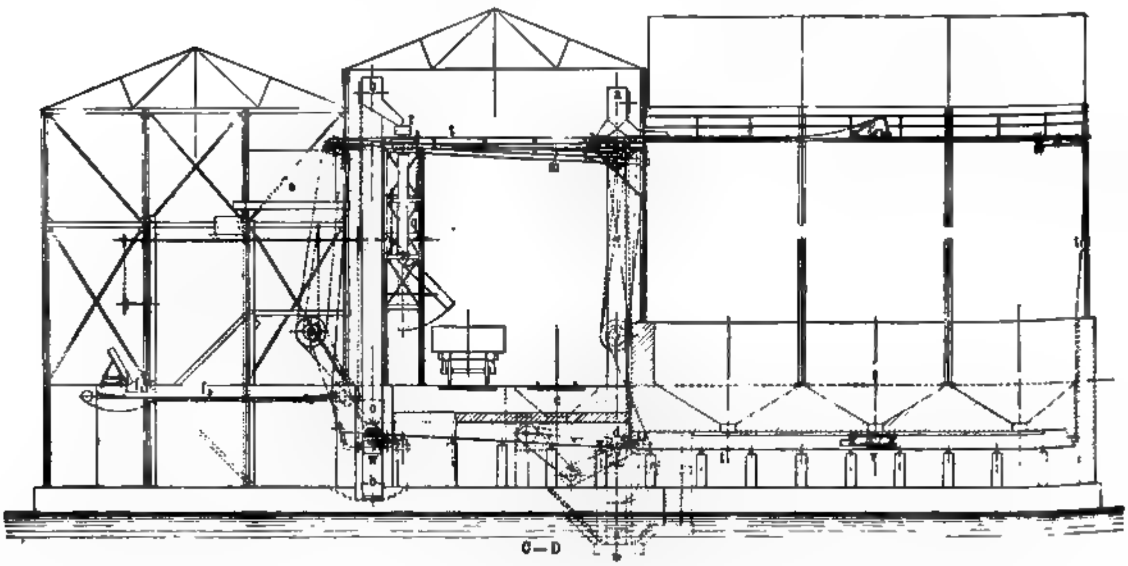

Fig. 451. Elevation of Model Coal-handling Plant for use in Gas-works.

Figs. 451 and 452 show such an installation in plan and elevation.

This plant is designed to take the coal as it is received by the railway trucks, deposit it in the coal store (which occupies more than one-half of the warehouse space), and when required, to deliver it to the hoppers over the retorts. It is further designed to so convey the coke from the retorts to the coke store that it can easily be withdrawn without manual labour.

Between the retort-house and the coke and coal store is a receiving station, through which pass two lines of rails. The coal is received and raised by elevator

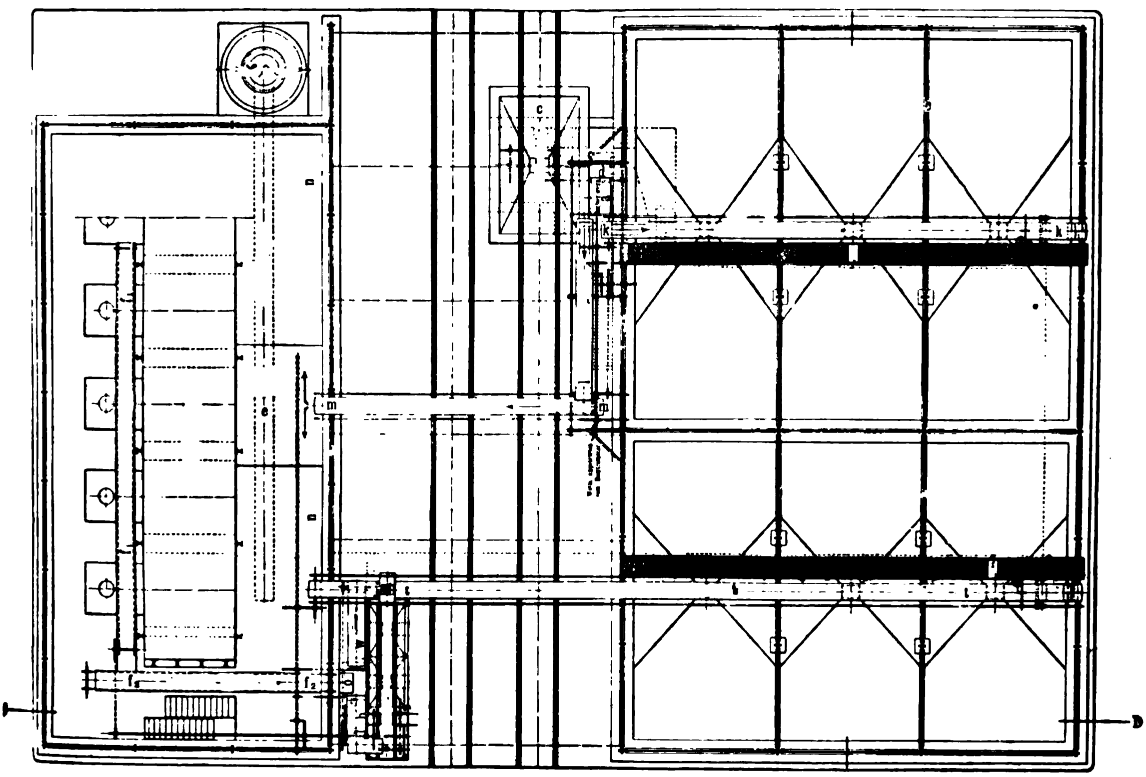

Fig. 452. Plan of Model Coal-handling Plant.

a, whilst the coke is similarly treated by *b*. The coal elevator *a* has been placed in the receiving station in such a position as to give easy delivery to the receiving band for conveying to the coal store. The same elevator is also used for conveying the coal from the store to the retorts, or if desired, the coal can be taken from the railway trucks direct to the retorts. The coal on arrival is rapidly unloaded by self-discharging railway trucks, and is dumped into hopper *c*, whence it passes by means of a shaking sieve to the breaker *d* and thence to elevator *a*. The coal small enough to pass the shaking sieve goes direct to the elevator; the remainder is first passed through a coal-breaker and then conveyed to the elevator.

The elevator *a* delivers by a double shoot and valve, either on to conveyor *k* which feeds the coal silos, or to band *t* passing to hoppers *e* over the retorts. Conveyor *k* is

Fig. 453. Coal-handling Plant at the Darmstadt Gas-works.

similar to Fig. 62, the bottom half being used as well as the top half, and is supported on rollers beneath the silos.

Another band conveyor marked *m* runs across the receiving station and can be fed to elevator *a* by means of an intermediate conveyor *l*. *m* delivers its load to another conveyor which conveys the coal into the coal hoppers. The coke handling is effected as already described in previous installations by means of a De Brouwer conveyor f_1, then by a similar conveyor f_2, from which it runs through a spout to breaker *o*, and is fed thence to elevator *b*, which delivers into a swinging conveyor, which is fixed above a series of hoppers, into which the conveyor, which is also a sifter, classifies its load.

An alternative way of handling coke is by means of band conveyor *t*, which deposits it in the coke silos, whence it can return to elevator *b* to be broken and classified, or to be loaded without further treatment, into railway trucks.

Coal-handling Plant at the Darmstadt Gas-works.—The plan described in the last installation has been adopted in this case with some slight modifications. A Bradley conveyor is, however, here used, running through the whole of the building, as shown in Fig. 453.

The top strand is high enough to feed three band conveyors. These deliver to the coal silos in the store which are hopper-bottomed, and are each provided with fifteen Weiss feeders (which are illustrated in Fig. 98, page 88). These deliver the coal into three swinging conveyors placed in tunnels beneath the silos, the delivery ends being visible in the illustration, and also the shoots which lead the coal on to the bottom strand of the Bradley conveyor.

Fig. 454. Coal Waggons Discharging their Load.

The coal thus taken from the store is conveyed by means of the Bradley conveyor to the top of the building, where it is fed into push-plate conveyors. These in their turn fill the coal hoppers over the retorts.

Coal-handling Plant at the Nuremberg Gas-works.—This plant is on similar lines, but in this instance two Bradley conveyors are used, with a capacity of from 45 to 50 tons per hour. The coal waggons here discharge their load into hoppers (see Fig. 454).

The large coal is then conveyed to the coal-breaker, after the "breeze" has been sifted out. Having left the breaker, it is deposited in one of the conveyors. The advantage of having two conveyors is obvious, as in the first place two railway trucks can be discharged at almost the same time, and further, one of the conveyors can be used for taking coal from the store to the retort house, while the other is receiving coal. Having the Bradley conveyor in duplicate is also a great safeguard against breakdowns.

A section through the installation is shown in Fig. 455.

Fig. 456 shows a section through the coal stores. In both views the band conveyors at the top and the swinging conveyor beneath the silo bottoms are clearly shown. Fig. 457 gives a small scale plan of this complete installation.

Fig. 435. Section through Coal-handling Plant at Nuremberg Gas-works.

Coal and Coke Handling Plant at the Winterthur Gas-works, Switzerland.—A further plant, also designed by the Berlin Anhaltische Maschinenbau Aktien-Gesellschaft, is illustrated in Figs. 458, 459, 460, and 461.

This installation is that of the Gas-works, Winterthur, Switzerland. Here the coal is received and then removed in skips by a suspended railway (Fig. 461) from the store to the inclined conveyor C, which delivers the coal to breaker B, whence it is removed to elevator A, which in turn delivers to the push-plate conveyor D (Fig. 458). This latter is made with a bottomless trough, so that the coal is automatically deposited into the hoppers E consecutively. No adjustment is required, and the coal will be conveyed to the first hopper which may happen to be deficient.

The coke falls from the inclined retorts into the De Brouwer conveyor, F_1, from which it is delivered into conveyor F, and from there again to a sorting swinging

Fig. 456. Section through the Coal Stores at Nuremberg Gas-works.

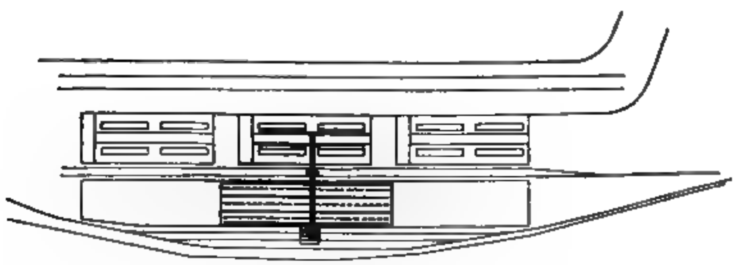

Fig. 457. Small Scale Plan of the complete Installation.

conveyor (Figs. 459 and 460) of similar construction to the one already described in previous installations. The sorting appliance is shown in longitudinal elevation and also in cross section.

Coal-handling Plant of the Avonbank Power Station, Bristol.—Fig. 462 shows the arrangement of a coal-handling plant erected at the Avonbank Power Station of the Bristol Corporation. A combination of Hunt's patent conveyor and automatic railway is used in this plant, the latter being employed for carrying the coal from the receiving hopper and weighing machine on the river-side to the chute which feeds the "Hunt" conveyor.

The automatic railway waggon receives coal from a weighing machine on the tower, descends by gravity along the incline to a filler pit, into which it deposits its load and

returns by means of the accumulated energy as already described.* From this point the coal is dealt with in the ordinary way, being fed through the automatic filler, after which it is carried upwards and inwards and dumped into the overhead bunkers, whence it is discharged by chutes into the stoker hoppers, the capacity being about 40 tons per hour.

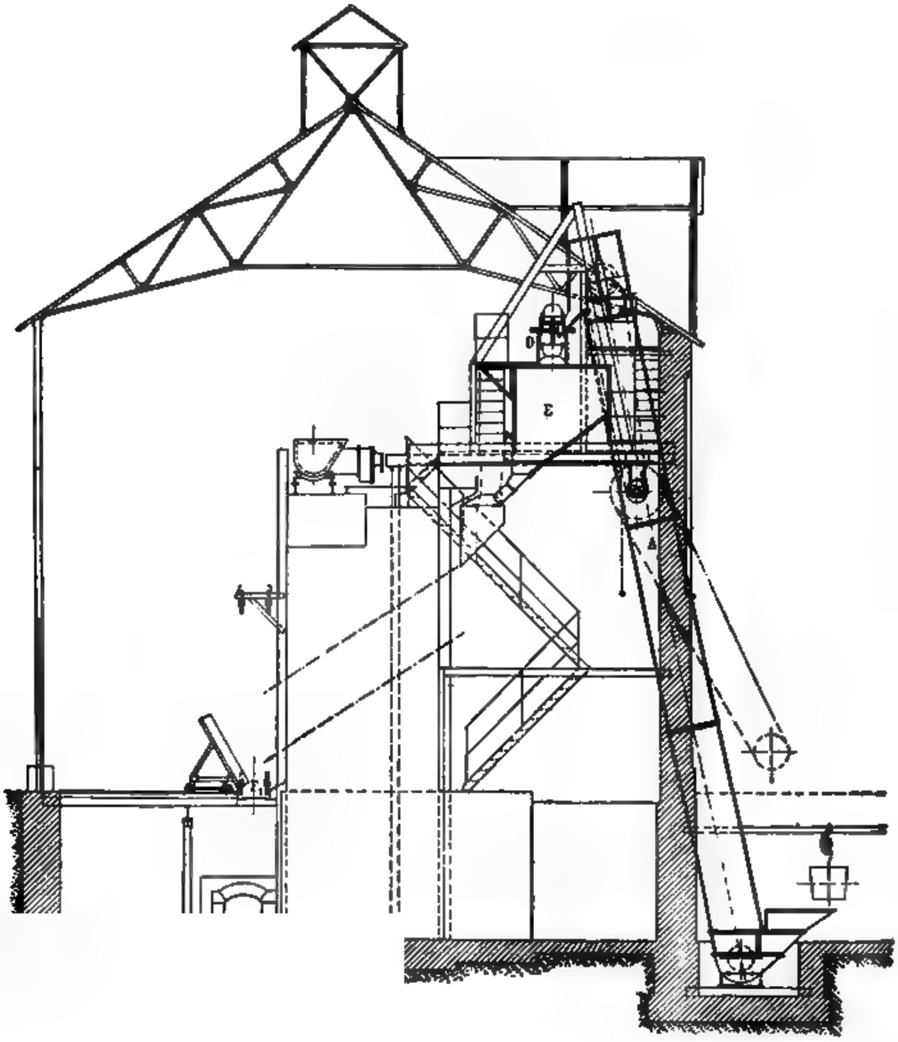

Fig. 458. Cross Section through Retort-house of the Winterthur Gas-works.

As the coal used at this station is of a specially fiery nature, the plant has been provided with an arrangement for retrimming, as shown in the illustration. To this end the coal bunker is fitted with four chutes, through any one of which the coal when desired may be discharged into the conveyor by means of the movable filler which is placed over the latter on the track beneath the boiler-house floor.

* For further description of "Hunt's" automatic railway see page 290.

Coal-handling Plant of the Aston Manor Electric Power Station.—A "Hunt" conveyor is also used in this installation, the normal capacity of which is 22 tons per hour. This can be increased if necessary to 25 tons, and all the ashes can be discharged at any time without interference with the coaling.

Briefly, the method of coal and ash handling is as follows:—

The coal (small) is delivered in barges alongside the filler pit, situated under the

Fig. 459. De Brouwer Conveyor removing Coke from the Retort-house to the Classifying Machine at Winterthur Gas-works.

ash tower, and is shovelled by three or four men direct from the barges into a longitudinal receiving hopper, at the rate of 4 to 5 tons per hour per man, costing about 2d. per ton in wages. From the receiving hopper the coal is delivered by the filler into

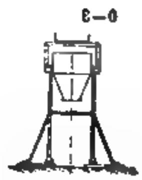

Fig. 460. Sifting Swinging Conveyor for Classifying Coke from the De Brouwer Conveyor into Different Sizes.

the conveyor buckets passing beneath. It is then carried inwards, ascending to the upper strand over the bunkers, where it is automatically dumped at any desired point. The buckets, after being dumped, descend and return under the boilers receiving the ashes by shovelling directly from the ash-pits. They are then carried outwards, towards, and over the ash-hopper, there dumping and descending to the filler pit again to be charged

with coal. The ashes can be retained in the hopper until convenient times for discharging, which operation can either be effected into barges or carts as desired.

The motive power is supplied by an electro-motor of the British Thomson-Houston enclosed type, which is geared directly on the first motion shaft of the "Hunt" driver.

This installation is the work of Messrs Babcock & Wilcox.

Coal-handling Plant of the South Staffordshire "Mond" Gas Co.—Fig. 463 illustrates this coal-handling plant. It consists at present of two conveyors, but the installation is about to be doubled. Each individual plant is of a capacity of 40 tons per hour. In this case the coal is brought in narrow "midland" barges, and from thence conveyed direct into an elongated receiving hopper. The hopper is of this shape to

Fig. 461. Coal-receiving Station at Winterthur Gas-works.

facilitate the discharge from the barges, and allows of a large gang of men being employed in the unloading. From these hoppers the coal is drawn to a conveyor by means of a filler. A conveyor afterwards moves the coal inwards and upwards, over and into the receiving hoppers, which are situated over the gas retorts, into which it can be deposited by means of regulating valves.

The conveyor is on the "Hunt" system, and has been erected by Messrs Babcock & Wilcox.

Coal and Coke Handling Plant of the Bristol Gas Co.—This is a very complete installation, and illustrates the mechanical handling of coke and coal in all its stages. It is the design of Mr D. Irving, engineer of the Bristol Gas Co.

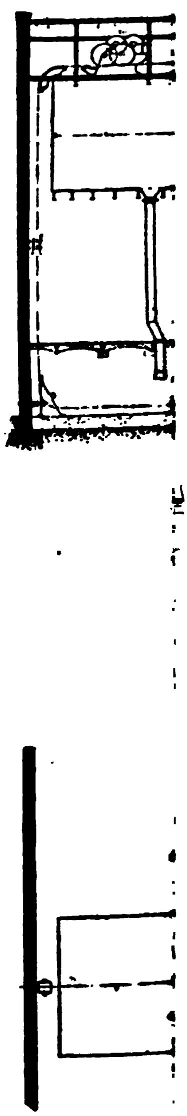

Fig. 464 shows the general plan and elevation of the installation.*

The coal is taken from the hold of vessels in the tidal river Avon, then weighed and broken to a suitable size to be further treated by the elevator and conveyor which remove it to the inclined retorts. These receive the coal without any such manual labour as would be necessary in the case of horizontal retorts. The coke, after carbonising, is removed from the inclined retorts by gravity, and is conveyed by a hot coke conveyor into a yard at the opposite end to that in which the coal is received. The unloading of the coal is effected by means of a steam crane and a Hone grab. This part of the installation is capable of dealing with 30 tons of coal per hour. The grab empties its load into a hopper and weighing machine which discharge either direct into the elevator well, or if the coal is not sufficiently small it passes through a coal-breaker before going to the elevator. The elevator discharges at the top into a push-plate conveyor which distributes its load into overhead hoppers. The elevator and conveyor as well as the coal-breaker are driven by a gas-engine of 12 HP.

The plant is of sufficient capacity to feed an additional retort-house which is in course of erection. The coal hoppers are fitted with the necessary measuring devices and spouts, to convey the coal from any of the hoppers to the retorts, which can thus be filled without any manual labour. After carbonising, the hot coke is removed by a conveyor fitted beneath the retort-house floor. The conveyor is suspended from the girders. Above it, along its entire length, are water pipes for quenching the coke as it passes on its way. Several of the conveyor covers can be removed at the point where coke is to be received, the remainder of the plates continuing undisturbed, so that the men in charge are not inconvenienced by the vapour always arising when hot coke is quenched. The plates move backward away from the retorts, so as to form a shoot for the reception of the coke, and at the same time shield the men in charge from the heat. The conveyor trough is 2 feet 3 inches wide, and is constructed of two channel irons with a wrought-iron plate riveted to the bottom, which is also fitted with a renewable iron strip. The return strand of the chain is carried overhead on guide pulleys. On leaving the retort-house the conveyor ascends an incline of 30 degrees and delivers the coke, first to the screen which removes the breeze, and thence by another conveyor which is partly inclined and partly level. This distributes the coal in a heap in the yard. The erection of overhead receptacles for the coke is contemplated, so that its discharge into waggons can also be effected without manual labour. The end of the coke conveyor extends so near the river bank that the coke can be loaded by a shoot into coke barges. The conveyor at its highest end is 23 feet above the ground, so as to command the stock heap. The coke conveyors and the screen are driven by an 8 HP. gas-engine erected in a small engine-house at the end of the building opposite to that in which is installed the gas-engine driving the coal-handling plant.

Coal-handling Plant at the Brentwood Gas-works.—The Brentwood Gas-works have a small but completely automatic coal-handling installation. Fig. 465 gives two elevations and a plan. The coal arrives in ordinary trucks with hinged-end doors; is then discharged by means of a hydraulic tip, and is deposited in a wrought-iron hopper capable of holding the contents of the truck, about 10 tons. The coal, after being broken in the coal-breaker, is elevated to the top of the coal store, where it is

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* The author is indebted to Mr D. Irving for the illustration which accompanies the above description.

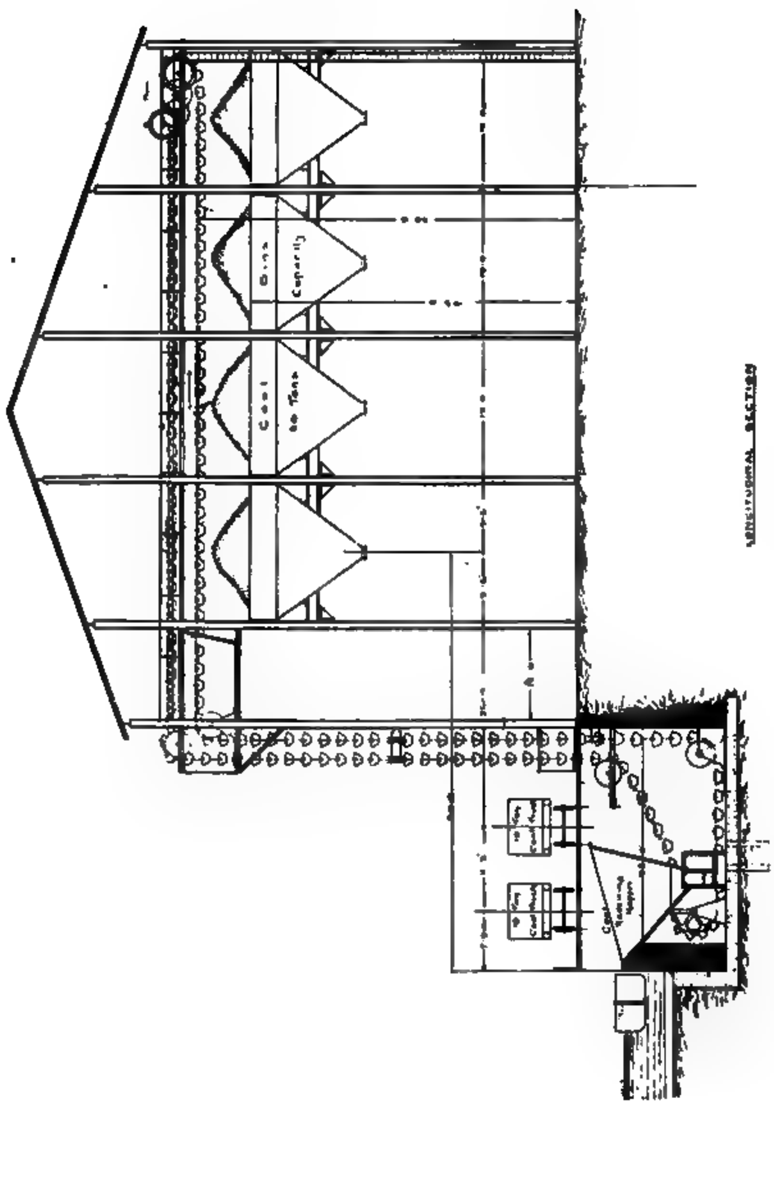


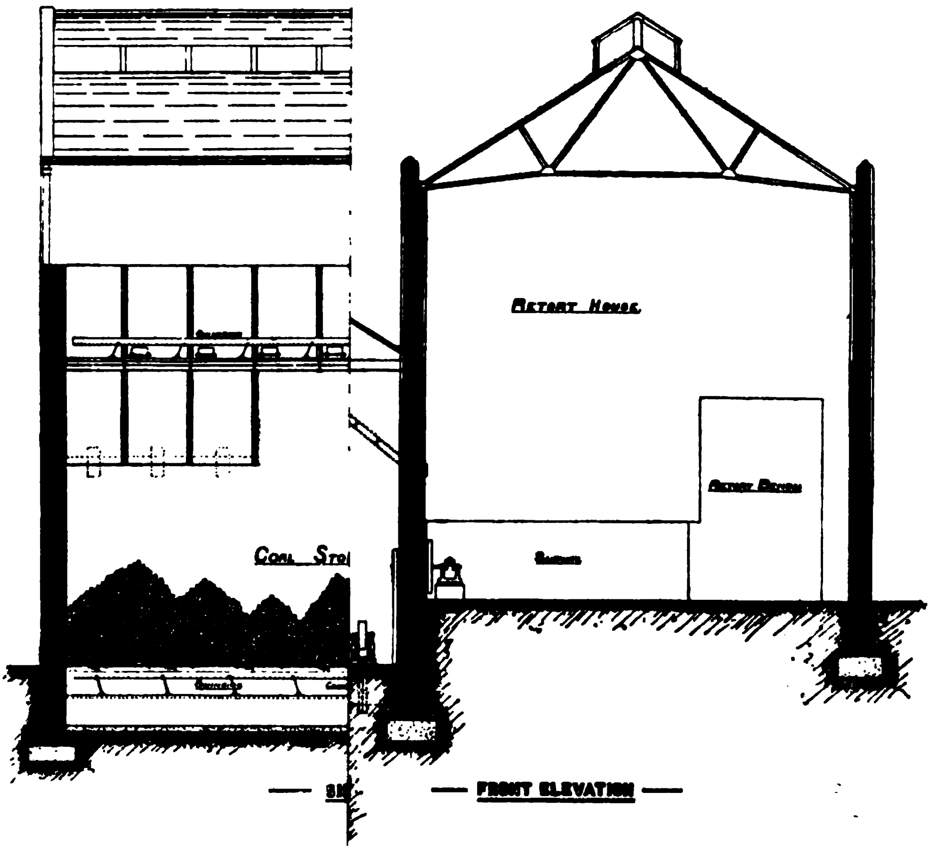
Fig. 463. Coal-handling Plant of the South Staffordshire "Mond" Gas Co.

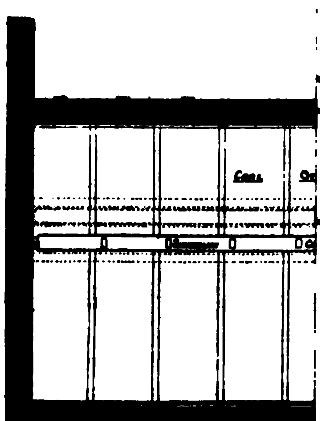
Fig. 464. Plan and Elevation of Coal and Coke Handling Plant of the Bristol Gas Co.

conveyed by a patent swinging conveyor to the extreme end, or to any intermediate point of the store. Beneath the conveyor are fitted six tipping shoots, by means of which the coal can either be dropped to the bottom of the store or into the coal-pockets, which are best seen in the cross section. These pockets are quite an innovation, and are the design of Mr R. M. Couper, the engineer of the Gas-works. They terminate in such a position that the scoop for feeding the retorts can be filled from them without the use of a shovel. Whenever the pockets are empty, and no coal is being taken in, the supply can be drawn from the coal store by means of a second swinging conveyor fixed in a tunnel under the floor of the store, when it can be elevated and conveyed by the plant already described.

The whole installation is driven by a steam engine of 10 HP. which manipulates the coal-breaker, the two conveyors, the elevator, and also the pump which works the hydraulic tip.

This installation was designed by the author.





TWOOD CAS WORKS —

T OF ELEVATING & CONVEYING PLANT —

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CHAPTER XXVIII.

FLOOR AND SILO WAREHOUSES FOR GRAIN AND SEEDS.

SILO warehouses are intimately connected with the mechanical handling of material, as grain and seeds must be conveyed to and from silos or floor warehouses by mechanical means, and the storage of grain in elevated silos will admit of its being withdrawn by its own gravity without the aid of manual labour.

Opinions differ widely as to whether floor or silo warehouses are most advantageous for the storage of grain. A silo warehouse has obvious advantages over a floor warehouse as far as labour saving is concerned, but it is also an undoubted fact that some grain, particularly home-grown English, and other soft wheat, is better stored in floor bins, because grain stored in high silos is subjected to great pressure, which has a tendency to raise the temperature of damp wheat. If it must be stored in silos it is necessary to turn it over at intervals.

The problem of how to store grain engaged the attention of the early Egyptians and of other nations of antiquity. Two distinct systems of grain storage were known to the ancients. The most primitive way was in all probability that of storing grain in pits or excavations in the ground, the object being to keep the grain as far as possible from contact with the air. This system is still in extensive use in Turkey and other Eastern countries, an instance in point being the rock pits of Malta in which wheat is stored to-day.

Later on another and radically different system was adopted, which is still used even in this country. This method consisted in spreading grain over a floor of hard earth or concrete, and of bringing it as much as possible in contact with the atmosphere by turning the layers of grain over from time to time.

In modern days the ancient practice (which is undoubtedly the most correct one) of more or less excluding the air from stored grain has been to a great extent reverted to.

When new grain is brought into a granary it begins to sweat, and a rise of temperature is perceptible as well as a peculiar smell, which proves that not only does water escape but also a volatile oil. There must also be an escape of carbonic acid, for the heating of the grain can only be produced by the combustion of some of the solid substances, the starch being likely to suffer greater reduction than the small percentage of fat and proteine. In order to keep the grain as nearly as possible at its right weight and in good condition it is necessary to prevent heating and only to promote evaporation of moisture artificially. This can be effected in various ways, the most common being to store the new grain in thin layers on the floor and turn it over frequently, until sufficiently conditioned to keep in silos. The method of turning wheat over in silos is less effectual, especially in the case of very new wheat, than the former method. When wheat is thus stored in thin layers the grains absorb oxygen constantly and issue carbonic acid in exchange for the oxygen taken up; they are in fact in a state of slow combustion. The hygroscopic nature of the grain is responsible for this action, as the

grain absorbs moisture in a damp atmosphere and gives off moisture in a dry atmosphere. According to Muntz, the more the air is renewed the moister the grain, and the higher the temperature the greater is the issue of carbonic acid. It follows then, from the above, that in order to store conditioned grain to the best advantage it should be kept in a dry and cool place and the air excluded as much as possible.

Some experiments as to the keeping quality of grain were made by Mr Doyère,* who in 1820 constructed a silo in which grain was kept for eight years. When the French Government ordered an investigation of the subject in 1855, Mr Doyère reported that the system of storing grain in silos greatly retarded decay, and that corn containing 21 per cent. of moisture and in contact with the air gave off 17 milligrams of carbonic acid per kilogram per hour, or 408 milligrams per day, while with the air excluded and at an average temperature of 68 degrees Fahrenheit, the carbonic acid given off per day was only 120 milligrams. From this it would appear that grain exposed to air decomposes three and a half times as fast as when stored in enclosed silos. The experiments of Professor Tyndall † and of the late Mr Pasteur also bear out this conclusion.

The above of course refers only to the storage of grain in good and sound condition. New and damp grain containing a large percentage of moisture would not be safe from decomposition even if stored in perfectly air-tight silos. Such grain must be dried or conditioned artificially, stored in shallow bins, and turned over frequently until it is in a suitable condition for keeping.‡

The origin of grain warehouses is attributed to Hungary, but these early examples were comparatively small structures, and do not appear to have been provided with any noteworthy appliances for the mechanical handling of grain.

It is to America that the credit belongs of designing granaries capable of holding immense quantities of grain and seeds, and of equipping these warehouses with machinery to obviate as far as possible the necessity of employing hand labour in the handling of the grain. In these warehouses (known in America as elevators) air is excluded as far as possible, but in all modern granaries there is this important departure from the original method, that the grain is stored, not in the earth, but in silo bins or some other structure above ground.

Although the United States of America owe the premier position among grain-exporting countries of the world first and foremost to the possession of a vast and fertile area of arable land, yet the adoption and systematic development of mechanical appliances for the handling of grain must have proved of inestimable service in the gaining of their colossal trade.

Silo warehouses § have been known in America since 1846, when they first came into general use, and large installations have since then been erected at all the most important grain-producing centres, as well as at the points where grain is exported. It was not, however, until the beginning of 1880 that the first silo warehouse of any great capacity was built in New York. One of the most valuable features of the American silo system is this, that it enables the agriculturist to store his grain cheaply under the best con-

* See "Conservation des Grains par l'Ensilage," by L. Doyère, Paris, 1862; and "Silos, Ensilage, and Silage," by Dr Manby Miles, New York, 1889.

† See "Essays on the Floating Matter of the Air," Second Edition, London, 1883.

‡ See Proceedings Inst. C.E., vol. cxxvi., Paper No. 2815, by P. W. Britton, on the "Transport and Storage of Grain."

§ To avoid misunderstandings, the term elevator (which is in America largely applied to these warehouses) has not been adopted in this book, as in this country the word is exclusively used with reference to ordinary elevating machinery and not to granary buildings.

ditions, and to hold it until the market is favourable to a sale. He can also mortgage his grain while he is waiting for a fair price.

In America this system has been carried out on an enormous scale. A holder can store his grain in a granary, say at Chicago, and can withdraw grain of a similar grade from some other warehouse, say at New York. In fact the grain trade there is carried on somewhat after the manner of the clearing house in the money market.

Silos, their Shape, and their Construction.—Silos may be either square, circular, or hexagonal, and may be built of wood, brick, concrete, or iron. The choice of material depends to some extent upon climatic conditions. The most suitable material for square bins is wood, for circular bins iron, and for hexagonal bins brickwork or concrete. Circular silos are the strongest, but are less economic in space than the other two forms. A large number of circular iron silos are used in America, the space between four large bins frequently being occupied by a smaller one.

*Wood,** as a material for building silos, appears to be most in favour, as it is light, strong, inexpensive, a non-conductor and hygroscopic. It has also the advantage of yielding to an unequal pressure or to a possible settlement of the structure. One of the most usual forms of construction is perhaps that known as the early American system, which consists of flat strips of wood nailed one on top of the other, and overlapping each other at the corners so that alternately a longitudinal and a transverse batten extend past the corner. Short pieces of timber are nailed down on the spaces forming alternate gaps, so that the whole silo wall is solid to the end. This is undoubtedly a strong form of bin, but it has certain disadvantages. The planks are liable to dry-rot and cannot be renewed except with great difficulty. They also harbour weevils if not frequently washed with lime. Fire risk is increased, the annual premium being 21s. per cent. against 3s. per cent. for a masonry warehouse. The importance of this difference will be appreciated when the value of the stored produce is taken into account.

Bricks or cement are suitable materials for the construction of silos, as they are bad conductors; they are, however, lacking in hygroscopic properties. The drawbacks to the use of such material are, its weight; the consequent necessity for stronger foundations, and the need for making the divisions thicker than when using wood.

Iron has the distinct advantage that the silo walls can be thinner than in the case of any other material, but its non-absorbent nature, and the fact that it is a good conductor, curtail its use for this purpose, as it transmits to the grain every change in temperature, and therefore causes condensation against the silo walls, with the consequent formation of rust and mould.

Ferro concrete is the material most largely used at the present day. If well constructed, no detriment will be caused to the structure through uneven expansion of the material. The first type was probably the Monier, followed by the Hennebique, and constructed of an iron or steel framework filled in with concrete, whilst the most modern construction consists of steel rods embedded in cement.

In the case of silo walls constructed of brickwork, these should be built in cement and not used until they are thoroughly set, or better still, hoop iron should be built in, at least at the end walls. Fig. 466 shows the results of non-observance of this rule. The illustration represents the collapse of the end wall of a silo warehouse at Isleworth on the Thames. The brickwork of the wall and the grain contained in the five end silos were all deposited on the adjacent ground.

* Paper by Mr P. W. Britton on the "Transport and Storage of Grain."

Granaries at the Liverpool Docks.*—These granaries were probably the first of any note to be erected in this country and fitted with mechanical appliances for handling grain, and although they are not silo warehouses, they are here described on account of their historic interest.

In 1868, to meet a want that had been long felt in the port of Liverpool, there were erected for the storing and conditioning of grain large blocks of warehouses fitted with mechanical appliances designed by and executed under the supervision of Mr Lyster, the

Fig. 466. Collapse of End Wall of Silos at Isleworth.

docks engineer. Although erected for this particular object, the warehouses were at the same time so designed and constructed that they could be used as ordinary goods warehouses, a large portion of the warehouse plant being available for the handling of general goods. The plant of these warehouses is designed for loading and discharging grain in bulk or in bags, also for transporting grain into different parts of the building and for ventilating it.

* From a Paper by Percy Westmacott, Proceedings Inst. Mechanical Engineers, August 1869.

The largest vessels can lie alongside, and can be discharged either directly on to the quay, or their cargo can be conveyed to the top of the warehouses or to any of the floors. Proper accommodation for rail and road traffic is provided, and goods are discharged or loaded direct from or into waggons or carts. The warehouses on the Liverpool side are situated at the Waterloo Docks, and contain an aggregate storage area of $11\frac{3}{4}$ acres, including the quay floor. Those on the Birkenhead side are erected on the margin of the great float, and have an area of 11 acres.

The warehouse plant is similar in principle and construction at both warehouses.

The dock around which the blocks of warehouses on the Liverpool side of the river are situated is 570 feet long, 230 feet broad at one end, and 180 feet at the other. Three sides of the dock are occupied by separate blocks of warehouses, connected by gantries. The blocks on the east and on the west sides are 650 feet long and 70 feet wide, while the blocks at the north end are the same width and 185 feet long. Each block contains five stories, as shown in the transverse section (Fig. 467). Above the top or fifth storage floor and partly in the roof some of the machinery is erected, while below the quay level are wells and arched subways to receive machinery. There are five discharging berths for large vessels, namely, one at the north block, and two at each of the east and west blocks. Additional accommodation is also provided for small vessels. In the centre or north block is placed a steam engine of 370 HP. which, in addition to driving the whole of the warehouse plant, supplies power for working the lock machinery and the bridges over the entrance.

Fig 467. Transverse Section through Portion of Liverpool Dock Granaries.

The returns of the grain imports into Liverpool for the six years 1858 to 1863, showed that it was desirable that these warehouses should be capable of handling 250,000 tons per annum, apart from ordinary merchandise. From an average of deliveries in Liverpool it was estimated that two-thirds of the grain would arrive in bulk and one-third in bags or barrels. The chief imports were from America, and vessels coming from that continent at that time, not being specially built for transporting grain in bulk, carried it in the hold, the decks being laden with breadstuffs in sacks, bags or barrels, and with other kinds of merchandise. Movable bulkheads were introduced into the forehold and aft and athwart, to prevent the bulk of grain from listing or shifting its position, and also to keep different kinds or different consignments away from each other as required.

These bulkheads and the generally limited size of the hatchway greatly hampered the quick discharge of grain in bulk out of ocean-going vessels. The principal operations to be effected by the aid of machinery were as follows:—

Discharging grain in bulk from vessels or small craft directly on to the quay. Discharging ordinary merchandise direct on to the quay or carrying it to any floor of

the warehouse, and loading outward-bound vessels. Lifting and lowering sacks, bags, and other merchandise on lifts and hoists to or from any floor. Elevating, screening, weighing, and distributing grain and conveying it to or from all parts of the warehouses to any other part and back again as required for conditioning damp or heated grain.

The best means of effecting these operations were the subject of much consideration and of many and costly experiments, particular attention being paid to the question of the kind of power to be used, and the most convenient, economical, and practical method of applying and distributing the power.

For this purpose a series of trials were conducted both with models and with actual machines. Taking into consideration the number and variety of the machines required and the intermittent action and high speed of many of them, the great distance and many different points to which the power had to be conveyed, and the desirability of bringing no machinery into action except at the particular points where work was actually to be done, it became obvious that no system of motive power at that time available collectively met these requirements with so much effect, economy, and convenience as the hydraulic system.

The two accumulators which controlled the water pressure employed as the medium for conveying power to the whole of the machinery employed in the Liverpool grain warehouses and dock entrances are situated at each end of the centre and north block of buildings. Between the west block and the river entrances is also placed a large auxiliary accumulator. The two accumulators in the north block are each weighted with a load of 70 tons, acting on a ram 17 inches in diameter with a vertical range of 23 feet. The water pressure is conducted through cast-iron main pipes varying from 6 to 3 inches in diameter, while wrought-iron branch pipes convey the pressure from the mains to the several machines. In order to economise the consumption of the water, which is obtained from the town supply, return pipes are laid on to conduct the exhaust water from all the machines back again to the well in the engine-house, from which the pumps draw their supply. Thus the same water is used over and over again. The pumps, engines, and boilers charging the accumulators are situated on the quay level. The engine is of the horizontal high-pressure type with two steam cylinders, the plungers of the double-acting force pumps being attached direct to the back of the pistons. The engine is made in duplicate in all parts, so as to admit of either side being worked separately if required.

It is capable of forcing 209,350 cubic feet of water per minute against the pressure of 700 lbs. to the square inch on the accumulator.

To determine the best means of conveying the grain horizontally from one part of the warehouse to another, a number of experiments were made with Archimedean screws or ordinary worms, and worms in revolving casings, but the great distance the grain had to be conveyed, amounting altogether to 7,000 feet, or about 1⅓ mile, and the power that would be required for conveying it, even with the best form of worm conveyor, rendered it expedient to seek some more suitable mode of transport, and recourse was finally had to endless travelling bands.

Trials were made with a band 18 inches broad, formed of two plies of stout canvas covered with vulcanised indiarubber, and this pattern was subsequently adopted for permanent use. The band was made continuous, extending over a distance of 37 feet, and supported upon plain cylindrical carrying rollers fixed at intervals of 6 feet apart, as shown at L in Fig. 68 (see page 61). The rollers were made of wood, with wrought-iron spindles revolving in bearings of white metal and lubricated with hard grease. The band was driven by shafting, and provided with a self-acting tightening apparatus similar

in construction to that finally adopted in the warehouses and shown in Fig. 68, consisting of a heavy tightening pulley M suspended upon the band and sliding vertically between the guides.

The maximum quantity of grain conveyed by an 18-inch band is at the rate of about 70 tons per hour, and it was ascertained that the power required to drive the band when fully loaded and delivering at that speed was infinitely smaller than with a worm.

In order to save labour in spreading the grain over the floors of the warehouses, and also to condition it by ventilation, a revolving fan with a scattering action was tried with success as shown at N in Fig. 467.

This fan, shown to a larger scale in Fig. 468, is keyed to an upright spindle driven from the main band by the same arrangement as that employed for driving the cross bands. As the band was required to travel sometimes in one and sometimes in another direction, the fan had to be made with straight radial vanes to make it work when revolving in either direction.

The grain is conducted by a spout on the top of the fan, so as to avoid the separation of heavy and light particles in the mass, and to spread the grain as evenly as possible over the floor, a conical form is given to the body of the distributing fan, whilst the alternate blades are made of a different length and shape as shown. By means of a valve placed in the end of the delivery spout above the fan, the discharge of the grain is directed to any particular spot by turning the valve round into the required position. The fan is placed 9 feet 6 inches above the ground, and at its usual speed of 250 revolutions per minute deposits the grain over an area of 45 feet in diameter.

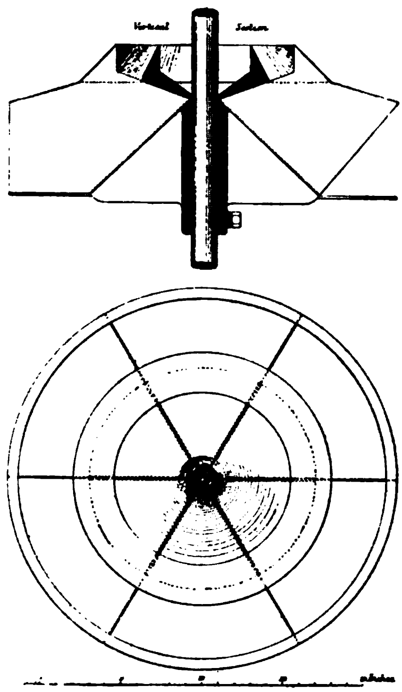


Fig. 468. Grain-distributing Fan.

Five hydraulic cranes for discharging vessels are fixed in towers specially constructed in the warehouses, one of which is shown at O in Fig. 467.

These cranes are arranged for raising grain in skips containing 21 cwts. of bulk, at a maximum rate of 50 tons per hour. They are also employed for landing sacks, casks, and other merchandise on the quay, or for delivering it to any of the floors of the warehouse. The lifting chain has an extreme range of 130 feet, and the jib an extreme projection of 24 feet beyond the quay. A traversing motion of 7 feet 6 inches is given to the heel of the jib, but this need only be brought into play for the largest class of vessels. The movements are all effected by hydraulic power under the control of one man stationed on a platform in the tower. The grain is filled into tubs or skips in the hold of the vessels, and there has been some difficulty in getting the right form of tub to meet all the conditions under which the work has to be done. The first form of skip employed was the ordinary tipping skip, which has by experience been found to answer best for the discharge of salt, coal, gravel, &c. The next form tried was a skip that required no tipping, but was fitted with a cone to deliver through the bottom. The form that proved on the whole the most satisfactory requires no tipping, and is fitted with a butterfly

valve in the bottom. When this skip is in position for emptying into the upper receiving hopper P, Fig. 467, the valve is opened by a lever on the platform from which the crane is manipulated. The time occupied in emptying itself by this form of skip shows a wide difference in the rapidity of flow of various kinds of grain. With wheat in good and dry condition it empties itself in five seconds, with barley in seven seconds, and with Indian corn in nine to ten seconds.

The hopper P (Fig. 469) into which the grain is dropped from the skip holds about 8 tons of grain, and from this hopper the grain is diverted into two streams, and allowed to flow through spouts fitted with regulators on to two 18-inch inclined bands Q.

These bands are driven by one hydraulic engine. One of these bands would be sufficient to carry the grain delivered by the crane, but two are employed so as to give greater spread to the material, and to facilitate the separation of the grain from the dust, should this be necessary. The separation is simply effected by an inclined flap fixed to the inner receiving hopper (see Figs. 467 and 469) into which the two bands Q convey the grain from the outer hopper P. From the inner hopper R the grain is allowed to drop through a valve into a ton weighing hopper S, after which it is delivered by a simple

Fig. 469. Grain Receiving and Distributing at the Liverpool Dock Granaries.

arrangement of doors in the bottom of the hopper, to either side of the distributing hopper T, whence it passes to one or other of the 18-inch bands I, which traverse the entire length of the warehouses. One man stationed at the weighing machine S regulates the flow of grain from the several hoppers, and records the quantity passed.

Two 18-inch main bands, made to run in either direction, are necessary for the convenient working of these warehouses. A vessel, for instance, lying at a berth at the west block of the warehouses may require its cargo deposited at either end of that block, or at any spot in either of the other two blocks, and at the same time another vessel lying at the east block opposite may have its cargo housed in the west block. Thus it often happens that two full streams of grain are being conveyed in opposite directions, and that a current of grain is carried right round the warehouses. The bands in the east and west block are again divided into two lengths; those connecting these two blocks and passing through the north block are in one length. Each band is fitted with a separate tightening gear, and is driven by a separate hydraulic engine of about 3 HP., having two cylinders, and fitted with reversing and regulating gear which can be controlled from any point along the entire band.

At each point where the flow of grain has to be diverted from the band on to the cross band, a fixed throwing-off carriage is stationed. Two movable throwing-off carriages are fitted to each main band, for casting the grain off into the wooden descending spouts, $8\frac{1}{2}$ inches square, which convey the grain from the top of the warehouse, and deposit it on any floor of the building. There are fifty-six of these spouts UU (Figs. 467 and 469), passing down from the upper machinery floor to the lower 12-inch bands in the arched subways VV below the quay level, and being provided with sliding doors at the different floor levels to admit of the grain being shovelled into waggons standing on the railway siding which traverses the centre of the block, or on to the lower 12-inch bands for conveying to the elevators. A number of other shoots are built at suitable intervals in the walls of the warehouses fronting the docks, at the levels of the several floors, and are each provided with a delivery outlet, to which a movable spout is hooked for delivering the grain from the warehouse into vessels. The arrangement of the machinery of the lower bands is a counterpart of the upper, but upon a smaller scale. The movable throw-off carriages provided on the upper bands are absent here, and indeed are not necessary, as these lower bands are only to convey grain from the descending spouts to any one of the five elevators W (see Fig. 469) which are fitted in the crane towers. The grain conveyed on these 12-inch bands is thrown upon the 18-inch cross bands, which deliver it into the hopper X supplying the elevator W. One 18-inch cross band will carry the full quantity of grain conveyed by the two 12-inch bands. The cross bands are arranged to receive their motion from either side of the main bands. Some of the grain removed from the vessels in sacks is sorted upon the quay, and is then emptied by hand into the hoppers X of the elevators.

Fig. 470. Grain-receiving Elevator at the Liverpool Docks Granary.

The construction of the elevators W (Fig. 469) for raising the grain from the bottom to the top of the warehouses is shown to a larger scale in Fig. 470. The wrought-iron skip W, capable of holding about 1 ton of grain, is slung from the lifting chain by an arrangement of bars and levers provided with guiding rollers running between upright timbers, which are so arranged that on arriving at the top the bucket tips over and discharges the grain into the top hopper Y. This hopper delivers the grain upon the same inclined cross bands Q that convey the grain from the outer crane hopper P. The bottom hopper X feeding the elevator is made in two sections, the upper of which, protected by a grating, receives the bulk of the grain.

The lower compartment Z contains only about one charge at a time for the elevator bucket W, and is separated from the upper portion X by a sliding valve. In descending, and on approaching the bottom, the bucket has its speed checked, and it then strikes the

arm of the tappet lever A which closes the valve between the two compartments X and Z of the hopper. Continuing its descent still more slowly, the bucket strikes another tappet arm B, which disengages the iron flap C that covers the front of the lower compartment Z. This flap, falling forwards by the weight of the grain behind it, acts as a shoot for delivering the grain from the lower hopper Z into the skip W. As soon as the skip has received its charge, the motion is reversed for lifting. In beginning to ascend at a moderate speed the skip again closes flap C of the lower hopper, which is held up against the hopper (as shown in dotted lines in Fig. 470) by means of spring catches DD. The bucket then strikes the tappet lever A of the hopper valve, and reopens the communication between the two compartments X and Z of the hopper. The speed is then accelerated until the bucket arrives within a short distance of the receiving hopper Y, when the speed is again retarded before the grain is shot out. The motion of the skip is regulated by self-acting gear. These single-bucket elevators are intended to raise the grain at the rate of about 50 tons per hour, but are capable of being worked at a higher speed. The chain of the crane O is used for lifting the bucket of the elevator, the same chain being applied to the crane according to the requirements of the work, but it has been found expedient on account of the demands of the traffic to make the elevators independent of the cranes, and to this end separate hydraulic cylinders with their adjuncts have been supplied for working the elevator.

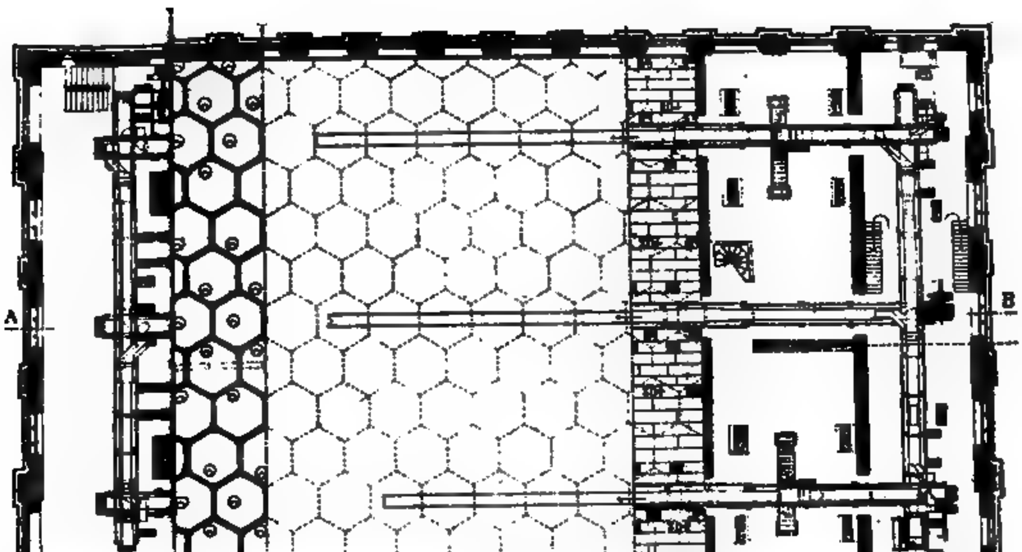
The clear aggregate storage area of all the floors, except quay and silo spaces, is 48,918 square yards, and at 4 quarters per yard would give a storage capacity for say 196,000 quarters of grain. There are six silos constructed of bricks, and capable of containing 3,500 quarters, the total storage thus being 199,500 quarters.

Granaries of Braila and Galatz, Roumania.—Amongst the first silo warehouses of any great capacity that were erected in Europe for the storage of grain were the silo warehouses of Braila and Galatz, in Roumania. Roumania is essentially a grain-producing country, and her prosperity largely depends on her exports of grain and seeds.

Late in the eighties the Roumanian Government realised the importance of erecting modern granaries in the two chief ports, Braila and Galatz, and the sum of 21,500,000 francs was allotted for that purpose. The credit of designing these two great granaries, the general plan of which, by the way, is practically identical, belongs to Mr H. Saligny, a high official of the Roumanian State railways. The entire mechanical plant of these two warehouses was supplied and erected by George Luther, of Brunswick, Germany, the contract being signed in 1887.

Before describing these granaries it may be well to dwell briefly on the grain trade of Roumania, which has increased by 50 per cent. between 1880 and 1888. Roumania affords a striking example of the economical use of grain-handling machinery where a great bulk of material has to be dealt with, even in a country where labour is very cheap.

The chief agricultural products of the country are maize, wheat, barley, rye, and oil seeds. In 1880 the export of grain from the Roumanian ports amounted to 1,324,090 tons; by 1888 it had increased to 1,951,905 tons. Approximately half the exports from Roumania go by steamer down the Danube and through the Mediterranean. Although Braila and Galatz are not exactly seaports, being both situated on the Lower Danube, yet they are accessible to sea-going steamers. As it is a ten hours' run from the Black Sea to Braila, it is in contemplation to economise by building a further granary at Constantia. Such a step appears the more essential seeing that at the rate at which the traffic increases, these two granaries will before long be inadequate to the demands upon



d Galatz.

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them. These two warehouses superseded a certain number of private granaries which existed at both Braila and Galatz. These were, however, one and all situated at some distance from the quays, and lacked modern grain-handling machinery. In those days the loading of ships with grain was a cumbrous and expensive process.

The Granary Buildings.—The marshy nature of the banks of the Danube precluded the building of the granaries on the river bank. It was therefore decided to excavate, both at Braila and Galatz, a basin 1,640 feet long by 400 feet wide, and to erect the granaries on the quay wall of these basins. In building both these silo warehouses, provision was made for doubling the installation at some future time should this be desirable.

Although these silos were built at some distance from the actual river bank, it was found necessary to erect them (as well as the quay walls) in their whole length of 1,640 feet on piles.

The illustrations show in cross section a tunnel of considerable dimensions for the accommodation of a band conveyor. Besides these there are along the quay walls at intervals of 23 feet, fifteen well-like receptacles of a depth of 20 feet and a diameter of 6 feet. These are connected with the above-mentioned tunnel by shoots. (The use of this tunnel will be more fully described later on.) There are also two transverse tunnels extending to the ends of the silo building. One of the sections shows these tunnels, which are all intended for the reception of band conveyors.

The silo-house lies back at a distance of 115 feet from the quay wall, the ground space occupied being 394 feet long by 92 feet wide. The height of the building to the eaves is 60 feet.

The granary with its accessories is also illustrated in Fig. 471, in which is given a small scale ground plan and two cross sections. Fig. 472 gives, to a larger scale, the plan of the granary in longitudinal and cross sections. Fig. 473 shows plan and four elevations of the engine and boiler house.

The foundations of this granary were laid on a system of more than 5,000 piles. In addition to this, the foundations of the building extend to a depth of 23 feet into the ground. Immediately on top of the piles is a layer of concrete which brings the level of the basement to 17 feet 6 inches below the outer ground level. Both ends of the building terminate in two higher parts to accommodate the staircases, elevators, automatic scales, and driving gears. The centre portion of the building which encloses the silos is covered by a roof with large skylights. The whole of the basement is intersected by tunnels which run the entire length of the building. These tunnels are each 10 feet high, and are intercepted at three points by cross tunnels connecting the nine transverse silos. Above these tunnels rise the silos themselves. They are 55 feet high, and of a hexagonal shape.

The building material used for these silos was Monier plates, which consist of cement slabs with wire insertion or foundation. These insertions project at the ends of the slabs, and when the latter are set in position, corner cavities are formed into which these ends are inserted. The cavities are then filled up with semi-liquid cement, which, when hardened, forms a solid block. The silos in both granaries are made in two sizes, about one-fourth of the area being occupied by cells measuring 8 feet 2 inches across, whilst the remaining cells have a measurement of 11 feet 6 inches. Between the silos and the northern annexe, in which the stairs, &c., are situated, is an elaborate grain-cleaning plant.

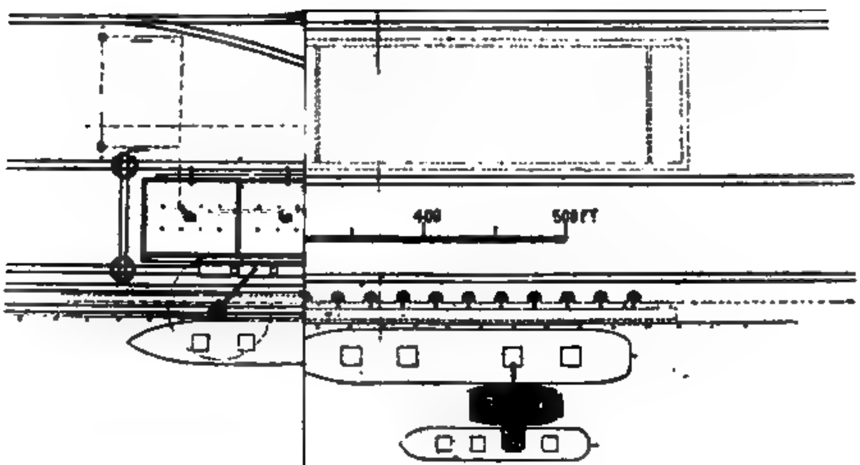
Further north still, in a separate building some distance away from the actual silo-house, is the engine and boiler house, the arrangement of which will be seen from Fig. 473. This building is divided into four sections, more than half being occupied by the

boilers, while one section is taken up by the steam engine. All these buildings are covered by an iron roof which is amply provided with skylights. The five boilers and the 500 HP. engines were installed with a view to the future extension of the plant. The engine is of the compound condensing type, with a high-pressure cylinder of 27 inches diameter, while the low-pressure cylinder is of 52 inches diameter. The stroke is 50 inches. The flywheel, built in eight sections, has a diameter of 21 feet, and is grooved for twenty 2-inch ropes. The engine makes 60 revolutions per minute. The water for the jet condenser is taken from the river basin. The southern portion of this structure which lies nearest the silo warehouse is raised above the roof of the engine and boiler house, and forms a tower which contains the main shaft, with its pulley, receiving the drive by means of the twenty ropes from the engine. There too is the hydraulic pumping installation. In the northern portion of the same building is the storekeeper's department on the lower floor, whilst the upper floor is set aside as a living room for some of the attendants. The granary is surrounded by a system of sidings, with turntables and hydraulic capstans, which greatly facilitates the work of loading trucks from, or unloading them into, the silo elevators.

The Mechanical Equipment of the Granaries.—The whole of the grain-handling plant with which the granaries are equipped is designed as much for the reception as for the discharge of grain.

At the edge of the quay are rails with a gauge of 11 feet 6 inches, upon which run two mechanical unloading appliances. The first consists of a telescopic elevator which can be lowered into ships or barges, and which raises the grain and delivers it to one of the two band conveyors at the head of the apparatus, each of which in its turn feeds automatic weighing machines with an hourly capacity of 75 tons. These weighing machines either discharge their load through a manhole in the ground on to a band conveyor which runs in the tunnel parallel to the quay walls, or the grain is again elevated by means of a second elevator in a slanting position, which delivers the grain at a sufficient height to render easy the loading of railway trucks on the siding which runs parallel with the quay (see Fig. 471). The driving power is provided by a pair of vertical compound engines of 35 HP., the steam being generated by two vertical tubular boilers. The boilers are fed by two water tanks. A turning gear, which can be driven from the engine or by hand, will so reverse the position of the whole apparatus that the portion which overhangs the water can be turned inland, or *vice versâ.* The whole of the apparatus is mounted on a platform provided with six wheels, the end ones of which are geared to the shafting and move the whole of the unloading plant by power. The unloading capacity is 150 tons of grain per hour.

For the purpose of loading ships the telescopic elevator is turned towards the granary, when it can be lowered into any of the fifteen grain wells which are constantly fed with grain by the longitudinal and either of the two transverse bands coming from the silos. The action is then almost identical with that of loading the grain from the boat to the railway trucks, with the exception that the sleeve from which the grain is delivered is lowered down into the ship's hold instead of into the grain wells. The second loading device is exclusively for loading ships with grain, and is therefore not reversible. It is built on a similar trolley to the last named apparatus, and is provided with two boilers and a 35 HP. engine, precisely as the last mentioned. There are two vertical elevators of the ordinary type, one of which fits exactly into the grain wells, into which it can be lowered, whilst the second elevator receives the grain from the first after it has passed through two weighing machines, whereupon it is finally discharged down the telescopic shoot into the ship's hold.



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The grain which is received from barges and other vessels, and is intended to be stored in the silos, is spouted to the longitudinal band conveyor, of which the upper strand runs from north to south, while the lower strand runs in an opposite direction. The strands are so far apart that both can be simultaneously used for conveying. Thus the grain can be taken from the barges either to the northern or southern cross conveyor, by spouting either to the lower or to the upper strand of a longitudinal band conveyor. In the same way grain may be taken from either end of the silos to any one of the fifteen grain wells as may be most convenient for the loading of ships moored at either end of the quay. Grain is distributed to the silos as soon as it is received by any one of the three band conveyors, while for discharging there are three similar bands in three of the nine tunnels below the silos.

The northern section of the receiving machinery, which is shown in the cross section (Fig. 471), contains four elevators in iron casings, the diameter of the internal pulleys being 4 feet by 28 inches. The northern cross conveyor terminates in the basement of this annexe; here, too, terminates the second cross conveyor, by means of which the grain is removed from one silo to another for ventilating purposes. On the upper floor in this same annexe is a further cross band conveyor, which distributes the grain raised by the elevators to any of the longitudinal bands which lead to the silos. There are also two short longitudinal bands for feeding the grain to the wheat-cleaning department. The same annexe also contains two centrifugal pumps for the purpose of removing any water which may find its way through the foundations. Provision is also made for sacking off the impurities removed from the grain in the adjoining cleaning department. Some of the motive power is also distributed from this section, the main shaft receiving 270 HP. from the engine-house, giving off its power to the third floor above the ground by means of two wire ropes. This is the whole of the power with the exception of the 80 HP. which is required for driving the grain cleaning, and which is conveyed to this department by a separate rope. A portion of the 270 HP. is conveyed from the main shaft just mentioned to the other end by means of another steel rope. The grain cleaning is very complete, and is fitted with cockle and barley cylinders to free the grain from all intermingled seeds. The whole of this plant is divided into two sections, each of a capacity of 150 tons per hour. There are also facilities for weighing the grain as it enters and leaves the cleaning department, so as to ascertain the exact percentage of impurities removed during the cleaning.

The deliveries from the band, &c., are connected with a strong exhaust, the function of which is to eliminate the dust. Some provision is made for dust rooms at the top of the building, in which the dust so removed can settle. The southern annexe is driven by separate wire ropes, as mentioned, and contains the terminus of the southern transverse conveyor, as well as a short cross conveyor similar to those on the other side which connect the elevators with the conveyors. It also contains the staircase and the hydraulic lift and appliances for sacking off the grain. There are four pits for the reception of grain arriving by rail, one at each corner of the building. These pits are each provided with two automatic weighing machines, which, in their turn, discharge the grain to the corner elevators which deliver it to the top bands.

The capacity of this granary is 233,333 quarters of grain.

The Alexandra Grain Warehouse, Liverpool.—This is of special interest, being one of the first installations of silo granaries in this country. An excellent description of this warehouse was given by Mr William Shapton in a paper read before the Institution of Mechanical Engineers, from which the following account has been taken.

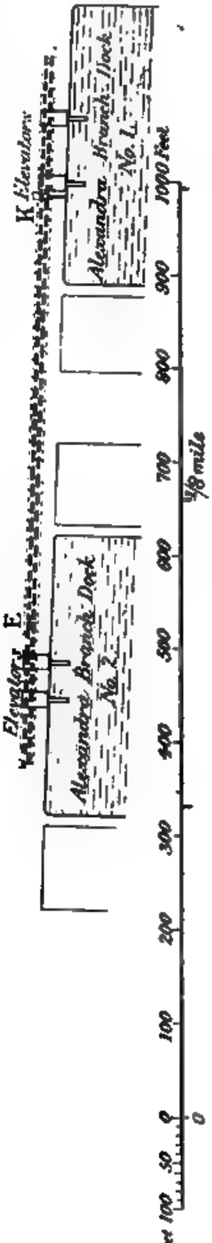


Fig. 474. Ground Plan of Alexandra Grain Warehouse.

The objects aimed at in designing this granary were:—Firstly, the greatest storage capacity on a given area of ground; secondly, economy of construction; thirdly, immunity from fire risk; fourthly, economy of labour in the several processes of discharging from the ships, receiving into the granary, turning over to keep the grain in marketable condition, bagging, weighing, and delivering into railway waggons or carts.

Fig. 475. Longitudinal Section through Granary of the Alexandra Warehouse, Liverpool.

Building.—As shown in the plan, Fig. 474, the building stands at a considerable distance from the dock-side.

On three sides it has direct communication with the London and North-Western, the Lancashire and Yorkshire, and the Midland Railways, for the delivery of grain.

Fig. 476 Dockside Receiving Elevators of the Alexandra Grain Warehouse.

The front is occupied by boilers, engines, and offices. The dimensions in plan are 240 by 172 feet, within which are contained 250 hexagonal bins of brickwork, each measuring 12 feet across the angles by 80 feet in depth, besides a large number of half-bins next to the main walls, which are used exclusively for delivering into sacks. The total

capacity of the bins is 80,000 tons. On three sides there are lean-to sheds in which the processes of weighing, sacking, and delivering are carried on. The walls of the bins are 14 inches thick up to a height of 27 feet, and 9 inches for the remaining 63 feet (see Fig. 475).

The top of each bin is provided with a fireproof cover, through which there are manholes with raised lips for the passage of the grain. These raised lips are intended to prevent water from penetrating into the interior of the bins.

Elevators.—The grain is lifted from barges by four elevators on the dock-side, and is conveyed to the granary on bands running in subways which pass under the quay and Regent's Road. At No. 1 Alexandra Branch Dock there are two outside elevators (Fig. 476), each having a nominal lifting capacity of 75 tons per hour.

The grain is elevated from the hold of the barges by these elevators, lifted 43 feet, and delivered into receiving hopper A, from which it is again lifted 32 feet by a second elevator inside the tower. It is then received into a second hopper B, thence it flows by gravity to a weighing hopper C underneath, which weighs 2 tons at a time, and delivers into a distributing hopper D beneath. This hopper holds enough grain to maintain a continuous feed for the band conveyors, and is at the same time of sufficient capacity to receive the intermittent deliveries from the weighing hopper C. Mechanical shovels or scrapers are employed in the hold for trimming the grain to the elevators, and are operated by ropes wound on a friction winch in the tower, which has an alternate reversing motion. The ropes are guided into the hold by snatch blocks, so as to move the scrapers alternately in a fore and aft direction.

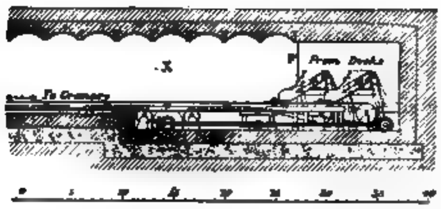


Fig. 477. Plan and Section of Subway under Quay and Roadway showing Band Conveyor connecting the Branch Dock with the Alexandra Grain Warehouse.

When it is desired to deliver the grain to the dock-side sheds instead of into the bins, it is discharged either through spouts from the top of the inside elevator, or from the distributing hopper beneath the weighing machine. Portable bands supported on trestles are used for removing grain from this point to the floors of the sheds.

At No. 2 Alexandra Branch Dock there are two similar towers with elevators and other appliances as above described, each elevator having 100 tons nominal lifting capacity per hour, but being capable of discharging and weighing at the rate of 145 tons per hour.

Band Conveyors.—The grain is carried from No. 1 Branch Dock elevators on two 18-inch bands to a point E (see Fig. 474) near No. 2 Branch Dock, from which it is thrown off upon either one of two 28-inch bands, and carried to the corner junction F (see Fig. 477). Here it is again transferred to another pair of 28-inch bands running

Fig. 478. Longitudinal and Cross Sections through Subway connecting Branch Dock with Alexandra Grain Warehouse.

Fig. 479. Plan and Elevation showing Receiving Elevators at Alexandra Grain Warehouse.

nearly at right angles, which deliver it simultaneously to any two of the three 150-ton main receiving elevators (see Fig. 479, which shows a plan and two elevations). These lift it 132 feet, and deliver it to three 28-inch bands on the top floor of the building.

The bands have movable throw-off carriages, which can be placed in any required position for throwing the grain into the spouts which conduct it to the bins. These three 28-inch bands command the entire range of 250 bins, or an area of 40,280 square feet. For delivering, turning over, and conditioning the grain, there are five 100-ton receiving elevators, and ten 22 inch bands, five of which are in subways below the silos, while five are above (see Fig. 475).

Movable hoppers conduct the grain from the bottom of the bins to the bands which convey it to the delivery elevators. These elevators deliver through hoppers G, H, and I to the top bands, which carry the grain back again, either to the bin whence it came, or to a fresh bin, thus thoroughly ventilating and separating it. For delivery into carts or railway waggons, the grain, after being elevated, is delivered into receiving hopper G, whence it is run into the weighing machine H by the attendant, who looks after the feed and discharge, and also records the weight. Below the weighing machine there is a

Fig. 480. Transverse Section through Granary.

Fig. 481. Delivery of Elevators to Granary.

delivery hopper I for receiving and conducting the grain to the delivery bins J (see Fig. 480).

These bins have spouts which pass through the external walls of the building into the delivery sheds, where the grain is again weighed, after which it is sacked and delivered to carts or railway trucks.

Delivery to Vessels.—For delivering the grain from the granary to the coasting vessels, a third band, not shown in the drawing, is laid in the subway, above the two receiving bands. This band is 16½ inches wide, and is divided into two lengths, the first running from the south-west corner of the granary to the junction F (Fig. 478), whence the second continues to K at No. 1 Branch Dock, where there is an elevator for lifting the grain sufficiently high to shoot it over the quay in bulk into the hold of the vessel, or for weighing and sacking it. The carrying capacity of the delivery band is 50 tons per hour, and the total length 1,270 feet, or nearly ¼ mile. As this band can be run in both directions, it may equally well be used for delivering grain from, or carrying it to the warehouse.

Motive Power.—The machinery in the granary, including the first length of subway

[*To face page 452.*

bands from the granary to the corner junction F, is driven by a pair of non-condensing Corliss engines with cylinders 27½ inches in diameter, and having a flywheel grooved for fifteen ropes. The speed is 60 revolutions per minute. The power is sufficient to elevate and carry 600 tons per hour, but one cylinder is sufficient for ordinary purposes, so that one-half of the engine is only needed in case of an emergency. Steam is supplied at 70 lbs. pressure per square inch by two Lancashire boilers. The 75-ton elevators and bands at No. 1 Branch Dock were driven by a semi-portable engine with two cylinders 11 inches in diameter by 18 inches stroke, having a grooved flywheel for rope driving. The steam pressure is 90 lbs., and the speed 120 revolutions per minute.

The 100-ton elevators and bands at No. 2 Branch Dock are driven by a similar engine, with cylinders 14 inches in diameter by 24 inches stroke, having a grooved flywheel which makes 90 revolutions per minute. The steam pressure is 80 lbs.

Elevators and Bands.—The 75-ton dock-side elevators have bands 18 inches wide, and buckets spaced 15 inches apart from centre to centre. The length of the elevator is 40 feet from centre to centre. The 100-ton elevators at No. 2 Branch Dock have 22-inch bands, and the buckets are spaced at 18-inch centres, the length of the elevator being 40 feet from centre to centre. The 150-ton elevators have 28½-inch bands, the buckets are spaced at 18 inches pitch, the length of the elevator being 128 feet from centre to centre.

The extreme distance the grain is carried, namely, from No. 1 Dock to the granary, is 1,680 feet or nearly ⅓ mile, and the total length of conveyor and elevator bands is 16,000 feet or over 3 miles. The elevator bands run at 8½ feet per second. The conveyor bands run from 9 to 10 feet per second. For hauling and shunting the railway waggons under the delivery floors, traversers and turnover capstans are employed, worked by hydraulic power. This power is also applied to the sack hoists, as it was found more convenient in its direct application than steam power, which would have to be transmitted by shafting.

Mixing.—It was found that the grain when falling into the bins left the chaff and light particles floating about in the air, with the natural result that the stored grain was of unequal density. Hence in drawing off for delivery the first served got the cleanest grain, whilst the last got the largest proportion of chaff. This threatened to be a serious objection to this mode of storage in silos until Sprague's mixer was adopted, which consists simply of a vertical pipe or spout running down the side from the top to the bottom of the bin, with openings through it at frequent intervals. These allow the grain to flow equally from all heights and to mix in its downward course through the pipe.

The building was designed by Mr G. E. Grayson, of Liverpool; the machinery designed and supplied by Sir W. G. Armstrong, Whitworth, & Co. Ltd.; Messrs Roberts & Robinson were the contractors for the building; while the electric light was supplied by Messrs Holmes & Vaudry, of Liverpool.

Granaries of the City of Stuttgart.—Before placing their contract the city authorities invited tenders, offering a prize for the best design. This, together with the order for the installation, was awarded to Rudolf Dinglinger, Coethen, Anhalt, Germany.

The warehouse is of the non-silo type, and the grain is stored on the various floors in bulk or sacks; other goods can also be warehoused. The engine-house accommodates two gas engines, and also the hydraulic installation for manipulating the lifts, &c. (see Fig. 482).

The grain is received by the elevator from the railway siding, and is delivered to the weighing machine, whence it is carried by a second elevator to the top of the building,

and fed on a band conveyor extending the whole length of the building. This is provided with a throw-off carriage which will allow the grain to be deposited in any part of the warehouse. The pipes reach from floor to floor, so that by means of the band conveyor and movable throw-off carriage the grain can be deposited on any floor of the granary from the one band conveyor at the top. There is a second band conveyor on a lower floor, which will take the grain from any of the floors, either to the elevator to be again elevated, or to be loaded. The second elevator is in the middle of the building, and can also by means of an alternate spout deliver to the hopper over the cleaning machine, whence the grain reaches the second hopper, the lower portion of which is fitted with a weighing machine for weighing the grain into sacks. The smaller of the four illustrations is a section through the engine-house showing one of the gas engines, a pump, and an accumulator.

Granaries at Breslau.—These were designed by Rudolf Dinglinger. The illustrations, Fig. 483, show a longitudinal section through the whole of the granary, as well as three cross sections. The cleaning plant is installed in the centre of the building, grain being stored on either side. One wing is provided with silos, the other is used for storing grain on the floor space. Since these granaries were designed, however, the scheme has been so far modified that the silos have been suppressed, the grain being stored only on the floor of the warehouses, the entire granary being fitted with floor bins.

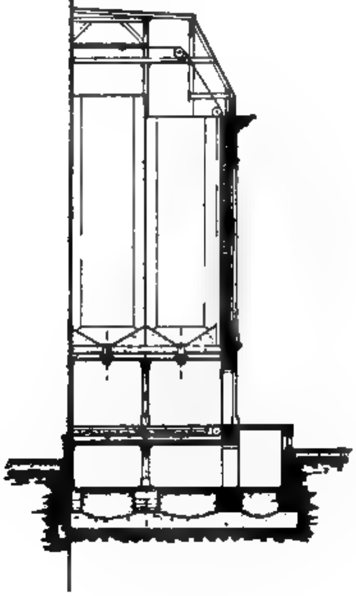
Grain is received at the centre of the building exactly in front of the cleaning department, either by rail, or by means of one of two barge elevators. After being elevated to the top of the building, it may either be passed through the cleaning plant, or it may be carried by a band conveyor to either of the wings to be stored. The top band conveyors are fitted with throw-off carriages, so that any part of the granary can readily be served. The lower strands of these band conveyors are also used for withdrawing grain and feeding the cleaning plant, which consists of a warehouse separator with a full system of cockle and barley cylinders for eliminating any seeds from the grain, which, when received, and prior to its delivery to either of the two elevators, is passed through an automatic weighing machine. There are also further automatic weighers through which the grain is passed before being sacked.

The barges can be brought alongside right under the receiving elevator, where they are discharged, as shown in the illustration.

This elevator is 36 feet long from centre to centre, and has a capacity of 40 tons per hour. It is so arranged that it can be lowered or raised to the level of the grain in the barges, and can also adjust itself to the water level of the river. The delivery of the elevator always takes place at the same spot. From this point the grain is removed through a spout to a second elevator, which in turn delivers it to the automatic grain scale, whence it passes through a grain-cleaning machine known as a warehouse separator, where it is again spouted to the elevator shown in the centre of the grain warehouse.

The receiving grain elevator can be raised or lowered by a small winch. The elevator itself is one of the chain type, with sprocket wheels at top and bottom, the framing being substantially constructed of angle iron and timber.

The wheat elevated from the barge is of course in an unclean condition; the weighing machine, however, keeps an accurate record of all material, dirty or otherwise, which passes in a continuous stream through the different elevators to the cleaning machines. The grain as it passes from these latter is by no means perfectly clean, but all such gross impurities as string, sticks, or any large foreign matters, as well as a certain amount of dust, have been eliminated in this preliminary process.



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Small Silo Warehouse Designed by Rudolf Dinglinger.—The annexed illustrations, Figs. 484-488, illustrate a silo warehouse designed by Rudolf Dinglinger.

It has a capacity of 700 tons of grain, and the silos have been built with masonry hoppers, whilst the upper part of the structure is of wood.

The installation consists of an engine and boiler house on the ground floor, which also accommodates a receiving installation. The grain can be received at either side of the building, either from farmers' carts or from self-discharging railway trucks, and can be carried from either side by conveyors HH to elevator J, which delivers it at the top of the building in a special lukem erected for the accommodation of the elevator head. The elevator discharges in the first instance into an automatic weighing machine, whence the grain can be conveyed to any of the nine silos. As the elevator has been erected nearly in the centre of the warehouse, it is possible to feed the silos without the aid of any conveying machinery. The contents of the whole of the silos can also be spouted back again to elevator J by means of cast-iron pipes in connection with the receiving band conveyors HH, which are also for the purpose of turning the grain over.

Some of the silos are not quite so deep as the others, and are for the accommodation of grain which has to be cleaned; from them it can be spouted to the cleaning machinery, from which it is removed to elevator J to be transported in a clean state into one of the other silo bins. Two of the nine silos have been subdivided, one in two divisions CC, and one into four divisions AA and BB. Subdivisions AA are intended for grain to be cleaned; BB for grain ready to be loaded into railway trucks. Silos CC are for damp wheat, and are furnished with steam pipes for drying purposes.

In the lettering on the plant, D represents the boiler, E the steam engine, F the fan, G the heating apparatus, H the band conveyor, S the elevator, K the cleaning machine, L the dust collector, and M the automatic weighing machine.

Silo Granaries of the Sun Flour Mills, Bromley-by-Bow.—This is one of the earlier installations of this class, and affords an excellent illustration of the timber silo. Figs. 489 and 490 clearly indicate the general arrangements of this warehouse. The wheat is distributed by adjustable barge elevators, ordinary elevators, and band and worm conveyors.

The granaries in question are situated on the Lea, and are placed by that waterway in direct connection with the Thames; whilst the Lea flows by one side of the mills, the other side is served by another waterway known as the Limehouse New Cut.

The mill is separated from the wheat warehouse by fireproof walls and iron doors. The grain receiving and handling plant was manufactured by Messrs Thomas Robinson & Son Ltd., Rochdale.

Fig. 489 shows a cross section through the receiving elevator, the preliminary gleaning, and the silos themselves.

In the silo warehouse itself the grain is distributed by means of a band conveyor which runs under the apex of the roof, and which has a throw-off carriage which is shown in Fig. 490.

By means of a system of spouts the grain can be deposited in any of the silos. The installation consists of thirty-three silo bins, each being 36 feet deep and 9 feet square.

The walls of each silo are constructed on the early American principle, which consists of planks nailed upon one another, and overlapping each other at the corners, as already described. The strips of timber used for these silos are 5 inches wide by 1½ inch thick for the lower portion of the silo; in the upper the battens are 3 inches by 1½ inch. The boards thus fastened together form wooden walls of great strength which

Fig. 484. Section CD through Dinglinger's Small Silo Warehouse (the dimensions are in metres).

can withstand the pressure from the grain in the silo. The silo bottoms consist of cast-iron plates which rest on girders and columns, the latter being supported on substantial concrete foundations. The columns, girders, and hopper bottoms are all shown in the illustrations.

The silos are utilised for three different purposes. Twelve are used for storage purposes only; fourteen others for the purpose of mixing the wheat; and six to receive same after mixing. This accounts for thirty-two bins. The remaining bin is solely used for the storage of English wheat, which does not arrive by water, but is brought to the

E F

D

Fig. 485. Plan of Dinglinger's Silo Warehouse (dimensions are in metres).

mill in trucks. An automatic weighing machine enables the operator to weigh the contents of any one of the silos for stocktaking purposes, and return the grain to an empty one.

Beneath the storage bin is a second band conveyor with a capacity of 25 tons per hour, provided with a movable hopper. This hopper can be brought underneath any one of the silos from which it may be desired to draw wheat. The grain thus drawn can be readily conveyed by band to an elevator feeding the other band conveyors at the top of the silo-house.

This second band is for the purpose of feeding the fourteen mixing bins, in any one of which wheat may be mixed in the required proportions.

These mixing bins are fitted with automatic mixers mounted on top of a worm, which mix the wheat in the required proportions, taking as much as is required from each silo to the worm. This mixing worm is in connection with another elevator, which feeds the worm over the top of the six blending bins. Beneath these blending bins is yet another worm into which the contents of any of these bins can be fed as soon as the wheat has laid together for a sufficient length of time, after which it can be thrown off and conveyed to the weighing machine before being removed into the mill.

Granaries at Mannheim in Germany.—These granaries, which have been erected at Mannheim on the Rhine by G. Luther, of Brunswick, have a length of 370

Fig. 486. Plan of Silo Warehouse, showing Section through the Silo.

feet, a width of 78 feet, and are 78 feet high. Their total capacity is 2,000 tons of grain. This granary is divided by transverse walls into three sections, one containing the silos, the second being used for storing grain on open floors, whilst the third or middle portion contains the grain-cleaning plant. This very complete installation is illustrated in Figs. 491 and 492.

On the quay-side, a large ship or barge elevator is connected with that part of the building which contains the wheat cleaning plant. There are four main elevators in the interior of the granary. The plant further consists of the necessary band conveyors, throw-off carriages, and automatic feeding devices, and of two elevators from the cleaning department. There is also a complete grain-cleaning plant specially designed for cleaning

barley. Means are provided for ventilating the silos in which new and damp wheat is stored. There is an elaborate system of pipes for distributing the grain to its several destinations. The whole plant is driven by electro-motors. That section of the warehouse not occupied by silos can be used for the warehousing of other goods, if not required for grain. With this view a lift has been provided for loads of 1 ton, and this extends from the cellar through all the floors, and therefore communicates with the whole of this portion of the building.

The elevators and conveyors throughout the installation are capable of dealing with 100 tons of grain per hour, whilst the barley-cleaning plant has a capacity of 5 tons per hour. This installation is so complete that four distinct operations are possible.

1. A ship may be unloaded into silos or into the warehouse floors, and may simultaneously be loaded either from the silos, or from the floors of the warehouse, with different kinds of grain.

2. A cargo may be unloaded either into silos or on the floor, and at the same time the grain may be cleaned.

3. Grain may be cleared from a ship, mixed with other grain that has previously been received, then fed into any desired section of the granaries.

4. Grain may be cleaned, mixed, and re-stored in any department of the warehouse, and transmitted from one ship to another.

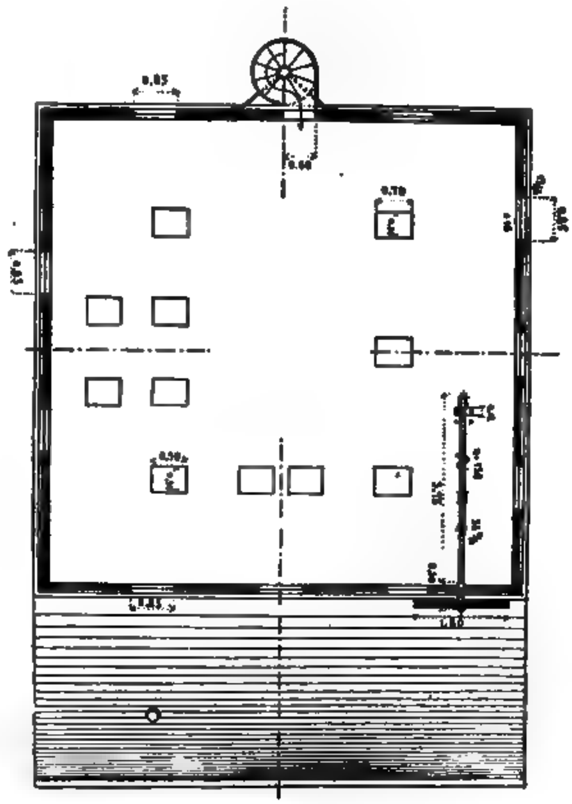

Fig. 487. Plan of Top Floor of Silo Warehouse.

The Granaries at Dortmund.—A grain warehouse possessing features of interest has been erected at Dortmund, in Germany, by the local Co-operative Society, from the design of F. Correll, civil engineer, of Neustadt an der Haardt.

The building is of brick on a base of hewn stone, all the beams and supports being of timber. This granary is built on the quay, and consists of two sections. The larger section is given up to the storage of loose grain in low bins on the floor, while the second or smaller section is a silo-house.

The building is 78 feet high, and consists of seven floors, including attic and basement.

The basement is chiefly used for storing provender and similar goods, in addition to which grain in sacks is also stored. The bulk of the grain is contained in the silos and on the five main floors. The latter section has accommodation for 1,675 tons, whilst in the silo bins about 825 tons can be accommodated. Thus the granary has a total storage capacity of 2,500 tons.

Fig. 488. Section EF through Small Silo Warehouse.

The silos are built on the American system, being constructed of planks 1½ inch in thickness, nailed one over the other.

In the four silo bins at the north (entrance) side of the building, grain can be stored

to a depth of 47 feet, whilst the available depth of the four bins on the south (canal) side of the building is 42 feet. Some of these silos have been specially prepared for the reception of damp wheat, and were christened "hospital" bins by the engineer. In these particular bins wooden arms are built in a transverse direction, and crossing each other, form square or diamond-shaped sections, thus breaking up the mass of stored wheat, and sensibly promoting the freer circulation of air through the bin by reducing the pressure on the lower layers. These wooden cross arms are of triangular section, and being slightly hollowed underneath, allow the air to come in contact with the grain. This air can be warmed if desirable.

On the five floors there are altogether 105 bins of moderate height. These bins are fitted with removable side walls, and the 21 bins on each floor lie exactly under or over each other.

Fig. 489. Cross Section through Silo Warehouse and Receiving Station of Granary, Bow.

Close to the windows on each floor are two bins which have been specially adapted for storing damp grain. To aerate these receptacles as much as possible, one-half of the side walls consist of an iron framework covered with a fine wire mesh which gives free ingress to the air. In these bins the grain is heaped to a depth of about 5 feet.

The grain as it reaches the warehouse is fed into the hoppers of the receiving elevator, which has a lifting capacity of 20 tons per hour, and carries the grain to a cleaning machine. The cleaned grain is passed over an automatic weighing machine, and is then either sacked or taken back through a spout to the elevator which has a lifting capacity of 25 tons per hour, and takes it up to the attic. From the head of this elevator the grain is either distributed to some bin on one of the floors of the main granary, or is sent to one of the silo bins in the silo-house.

It may be noted that the grain is carried through a spout and a belt conveyor to

one or other of the turntables, as the apparatus may be termed which serves to distribute the grain through spouts to any of the floor or silo bins, or, if it be desired, the grain can be shot again into the basement, whence it is conveyed to the main elevator to be turned over once again. Under the basement ceiling is a band conveyor which was erected for this purpose.

The turntables in the attic can readily be controlled from the floor below by means of a hand lever, and the grain directed into the required spout; thus, on arrival, it can be poured into any bin on the top floor. For its further distribution the following special arrangement has been provided. A vertical spout passes through the centre of each series of bins lying one under the other, whilst at the bottom of each bin are four apertures from which, by means of connecting spouts, the grain can be conveyed either into the bins on the floor below or into the main spout (see Fig. 494). This spout may be utilised for a variety of purposes; either for shooting grain through to the bottom of

Fig. 490. Longitudinal Section through Granary, showing Throw-off Carriage and Band Conveyor

the warehouse, or for mixing different kinds of wheat, without the flow of grain through the connecting spouts from one bin to the bin beneath being interrupted. By closing the connections between the delivery spouts of the bins on one floor with the main spout, grain can be taken from any of the upper floors into any of the floors beneath. This wide range of operation is rendered possible by the ingenious system of distributing valves designed by Mr Correll.

The working of these valves, which can be controlled from the basement by chains, may be seen from the illustrations. In Fig. 495 the simplest form of valve is shown in two views; *a* is the connecting spout through which grain may be taken, *viâ* the main spout, to any desired floor beneath, whilst *b* shows the mouth of the spout from which grain falls from a bin on any one floor into the bin lying immediately underneath on the floor below. If there is no necessity for taking grain straight away through one floor, the valve provided is as shown in Fig. 496.

Fig. 4aning Department.

[*To face page 462.*

If the valve be placed in a central position, the grain on the floor below can be mixed with grain from any floor above through the conduit *a*; and if it be desired to mix grain from several floors, conduit *b* is provided as part of the valve. From the different positions of the valves in Fig. 497, the direction in which the grain to be mixed must flow can easily be seen.

If it be desired to let grain through from one bin to its fellow on the floor below, and at the same time to carry grain to delivery spout *a* in a downward direction, one of

Fig. 492. Cross Section through Cleaning Department of Granary at Mannheim, showing Barge Elevator with its connection to the main Building.

the walls of conduit *b* is bent back, and takes a cup-like shape. This cup is open at the top with an outlet *l* at its lower end (see Fig. 498).

To prevent grain getting between the valves and their casings, slides are arranged over the valves, and are made to exactly fit a section of the casing.

At the quay-side of the warehouse an apparatus has been provided for clearing the grain vessels as they lie by. It is adapted to unload grain either loose or in sacks.

This unloading apparatus can handle from 150 to 300 sacks per hour.

The machinery inside the granary is driven by one electro-motor of 12 HP.

Spencer's Granary Floor Spouting.—A similar principle to that described in connection with the Dortmund granaries has been used by Messrs Spencer & Co. Ltd., of Melksham, for several years, and on these lines they have built a number of granaries.

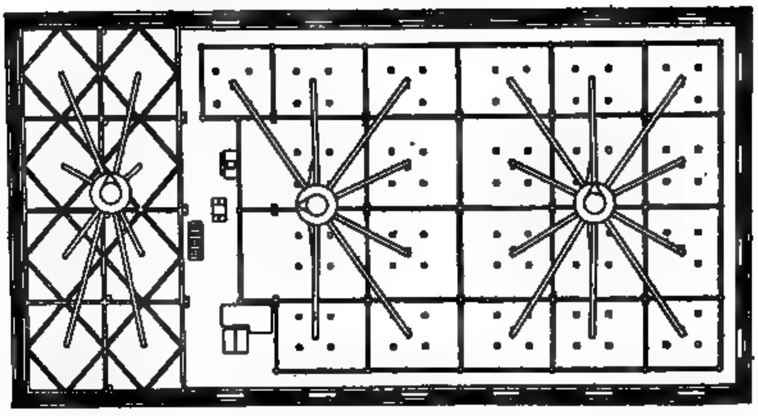

Fig. 493. Plan and Cross Section of Granaries at Dortmund.

There appears to be a growing tendency to store certain kinds of grain, especially home-grown wheat, in floor bins instead of in silos. Fig. 499 shows two devices adopted by Messrs Spencer to deposit the grain in a series of floor bins above each other, and to withdraw the grain from one bin to another for the purpose of turning it over. In the

section on the left-hand side this system is shown as applied to floor bins with level floors, whilst the right-hand section shows an installation for floor bins with hoppered bottoms. The latter are preferable, as they require no trimming whatever. The drawing will be readily understood by the aid of its descriptive legends.

Silo Warehouse at the London and India Dock Co.'s Docks.—This granary, illustrated in Fig. 500, has a total capacity of about 25,000 quarters, and is built on the American system, with an interlaced timber structure resting on iron columns. The walls are covered with an external steel casing. The total height of the building is over 100 feet; the silos are fifty-six in number, each about 10 feet square by 50 feet deep.

On the right of the picture is an intake plant, while on the left are the barges bringing grain from the large silos of the London Grain Elevator Co., which are about 100 feet distant. The intake plant has a capacity of 100 tons of wheat per hour, and includes appliances by which the grain is automatically weighed into the bins. There are six automatic grain scales, each weighing the contents of one sack at a time, on the sacking-off platform, which has an arrangement whereby it is always kept at the correct level for delivering to barges.

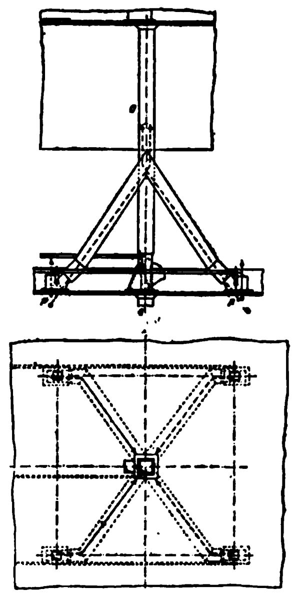

Fig. 494. Arrangement of Grain-distributing Spouts.

The main delivery floor of the granary is about 8 feet above ground level and is level with the tops of railway trucks. On this floor are a number of portable automatic weighing machines which can be placed beneath any bin, and so deliver to railway trucks or vans.

The whole of the plant is driven by electro-motors, one for each machine. There are two main elevators, two bands conveying at the top of the silos and two underneath, so that grain may be taken from barges, delivered to silos, turned over from one conveyor to another, or delivered to the weigh-out house and main delivery platform simultaneously.

This installation was erected by Messrs Spencer & Co. Ltd., of Melksham.

Grain Warehouse, Manchester Docks.—The general arrangement of this important warehouse is shown in Figs. 501 and 502, one being a general plan, and the other a perspective view. This granary, which is 448 feet long by 80 feet wide, was erected in 1898, the whole of the superstructures being built of wood on the American system with an external casing of brickwork and tiles.

The building has a storage capacity of 40,000 tons of grain. There are 226 bins, varying in capacity from 37 to 300 tons each.

The granary stands at a distance of about 340 feet from the side of the dock, where the tower and ship elevator are situated, being connected with the main building by a gantry with band conveyor. The elevator is capable of raising some 350 tons of grain per hour from the hold of a vessel containing a full cargo of grain. Arrangements are made in the tower by means of which the grain is weighed whilst being conveyed from vessel to elevator, the weight being there checked by both the representatives of the vessel and the owner of the grain. After the grain has been conveyed into the main

building, it is again lifted to the top of the central tower of that building, and thence distributed to the various bins.

Appliances for the delivery of grain upon an extensive scale into railway trucks, road vans and lorries, barges and coasting vessels (either in bags or in bulk), have been provided, and can be worked concurrently.

In addition to the ordinary method of discharging grain by means of ship elevators, one of Duckham's pneumatic elevators has been provided, which is employed *inter alia*

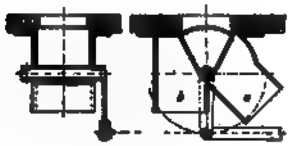

Fig. 495. Simplest Form of Grain-distributing Valve.

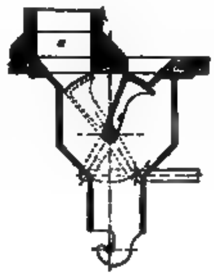

Fig. 496. Alternative Form of Grain-distributing Valve.

for dealing with small parcels of grain, and with grain stored in positions which cannot be reached by the ordinary ship elevator.

Power is supplied for the working of the elevator and the various band conveyors in the main building, as well as leading thereto and therefrom, by two sets of horizontal

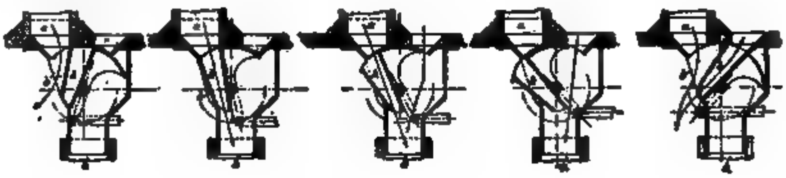

Fig. 497. Grain-distributing Valves in Different Positions.

Fig. 498. Grain-distributing Valves in Different Positions.

Corliss compound engines of 500 HP. jointly, fed with steam by two Galloway boilers working at 100 lbs. pressure.

The power for the pneumatic apparatus is provided by two sets of triple expansion vertical engines of 600 HP. supplied with steam by three boilers working at a pressure of 160 lbs. per square inch.

The following operations can be performed simultaneously at the warehouse:—

1. Discharging from vessels alongside at the rate of 350 tons per hour.

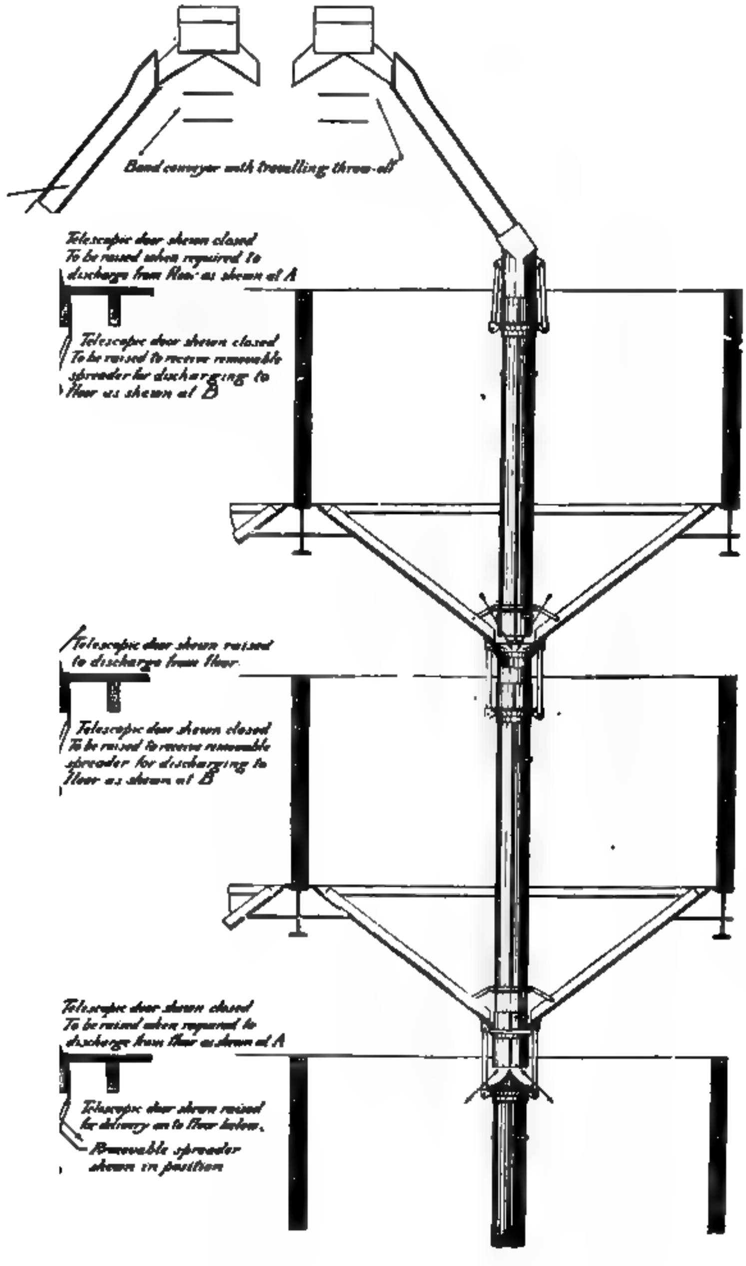

Fig. 499. Granary Floor Spouting.

2. Weighing in tower at the water's edge.
3. Conveying and distributing into any of the 226 bins.
4. Moving grain about for changing bins or for delivery, and weighing in bulk at the rate of 500 tons per hour.

5. Sacking grain, weighing and loading sacks into forty railway waggons and ten carts.

6. Conveying into barges or coasters at the rate of 150 tons per hour if in bulk, or 250 sacks per hour if sacked.

The author is indebted to Mr W. H. Hunter for the illustrations which accompany the above description.

The Transit Silos on the Thames.—These form a most interesting group of installations. Although only used as transit silos, they are silos in the fullest sense of the word, and therefore deserve to be mentioned in this chapter. They were built for the London Grain Elevator Co. by Spencer & Co. Ltd., and are situated on the south side of the Victoria Dock. They consist of four complete and independent installations. The

Fig. 500. Silo Warehouse at the London and India Dock Co.'s Docks.

area of the property owned by the Company is 50 acres, half of which is water, and the other half land. The space is oblong in shape, and is shown in the plan, Fig. 503. At each end three peninsulas project into the water, thus forming four docks of an area of 2 acres each for the accommodation of the barges. The water in these berths is of sufficient depth to accommodate all ships which can enter the Victoria Docks, so that the largest ships can have their cargo discharged, weighed, or transported into smaller up-river barges or to railway trucks. All these operations can be carried on under cover, and are therefore quite independent of the weather. The four transit silos, two of which are shown in the illustration (which also gives explanatory notes), are situated on the south-west and north-west peninsulas, leaving one peninsula for the probable further extension. Each silo-house marked C on the drawing is divided into nine bins or silos, eight of which are used for storage purposes only, whilst the middle space is used for the accommodation

Fig. 502. General View of Manchester Ship Canal Granary.

of staircases, elevators, &c. Each of the eight silos is 12 feet square by 80 feet deep, and has a capacity of 1,000 quarters of grain.

The silos are erected on a massive cast-iron tank forming a cellar which rests upon

Fig. 503. Transit Silos of the London Grain Elevator Co. at the Victoria Docks.

a concrete foundation 6 feet in thickness, the bottom of this tank being 30 feet below the water level. They are built on the interlaced timber system which has already been described, being formed of "battens" nailed on top of each other, the pieces interlacing.

The silo bottoms are so constructed that there are no joins in the corners, thus dispensing with rivets at these points, as they are apt to obstruct the flow of the material, and prevent the silos from emptying completely. These silos are supported on rolled steel girders which rest on cast-iron columns. The outside of the granary is covered with corrugated iron, and the roof is covered in a similar manner. The silos are about 100 feet high, and carry a substantial iron roof which also covers two gas engines for driving the three delivery elevators, one of a capacity of 120 tons per hour, and two of a capacity of 100 tons each per hour. There is no occasion for conveyors, as the elevators which rise above the tops of the silos can readily deposit the grain into any one of them.

In connection with each silo is a barge elevator having a capacity of 120 tons per hour, which is driven by a separate gas engine. This outer barge or receiving elevator discharges its load into the elevator well inside the warehouse. Each delivery elevator leads to a discharge shed in which the grain is weighed. In this shed is a large receiving hopper (marked E in the illustration), below which are six automatic weighing machines all fed from this hopper. After weighing, each machine discharges itself automatically into sacks, which are then ready to be loaded into barges or railway trucks. The four installations are all on exactly the same lines as the one described. Each pair of granaries is provided with one common sack conveyor band which is 308 feet in length, so that the full sacks can be carried to the railway trucks as soon as they can be got ready by twelve men in connection with each weighing shed. There is one gas engine for driving each of the two sack bands. These sack bands are so arranged that the speed can be either slow, to take sacks, or it may be higher for the purpose of conveying grain in bulk for loading barges or bulk grain cars.

The silos are generally fed by a fleet of twenty-six of Philip's patent self-discharging lighters.* These lighters are charged from ocean-going steamers at Tilbury, and towed by special steam tugs to the transit silos. Previous to the installation of these important granaries the grain had to be unloaded and weighed by means of a floating hopper which was exposed to all weathers, and the motion of the unloading elevator was not conducive to accurate weighing; but with the new machinery it is now possible to discharge at the rate of 100 tons of grain per hour from each hatch by means of the derrick elevator described on page 268. And whereas the lightermen had formerly to be at work night and day, the Company are now in a position to make all deliveries to receivers by daylight. The arrangements are so perfect that the grain which is loaded at Tilbury into the Company's lighters can be delivered to rail or private craft from the transit silos in six hours. The whole installation is driven by fourteen gas engines, three being employed for each silo-house and two for the sack bands. The gas engine for the intake or barge elevator is one of 20 HP., the one for the inside elevator 36 HP., the one for turning over and delivering the grain 28 HP., and the two for the sack bands 15 HP. each. The actual power consumed is, however, less than this. Gas has been decided upon as driving power, as the Company eventually contemplate producing their own gas.

Figs. 504 and 505 show two photographic views.

A Typical Modern Granary.—Fig. 506 shows a very compact granary equipped with interlaced timber silos. It consists of a balanced barge elevator with a range of 20 feet up-and-down motion, and with a capacity of 60 tons per hour. From this barge elevator the grain is spouted through the outer annexe into the silo warehouse, where it is lifted by the shorter elevator to a hopper, from which it passes through a weighing

* See page 274.

machine which weighs 1 ton at each charge; from there it is conveyed into a second hopper, and into a preliminary grain-cleaning machine; from thence again to a third elevator, which takes it to the top of the building, and delivers it into a series of silos

Fig. 304. Transit Silos of the London Grain Elevator Co.

by means of a band conveyor with a throw-off carriage. All the elevators and conveyors have a capacity of 60 tons per hour.

The silos are forty-six in number, and are 8 feet 6 inches square by 80 feet deep,

having a total capacity of 24,000 quarters. The whole installation is driven by electricity, and the plant has special facilities for mixing the grain as it is leaving the warehouse. It is also provided with a separate intake elevator of a capacity of 30 tons for

Fig. 505. Four Transit Silos of the London Grain Elevator Co.

the reception of English wheats. The whole warehouse plant is driven by three electromotors, one for the top floor with its machinery of 38 B.HP., a second driving the plant in the receiving annexe of 24 B.HP., and a third which drives the conveyors on the ground floor of 10 B.HP.

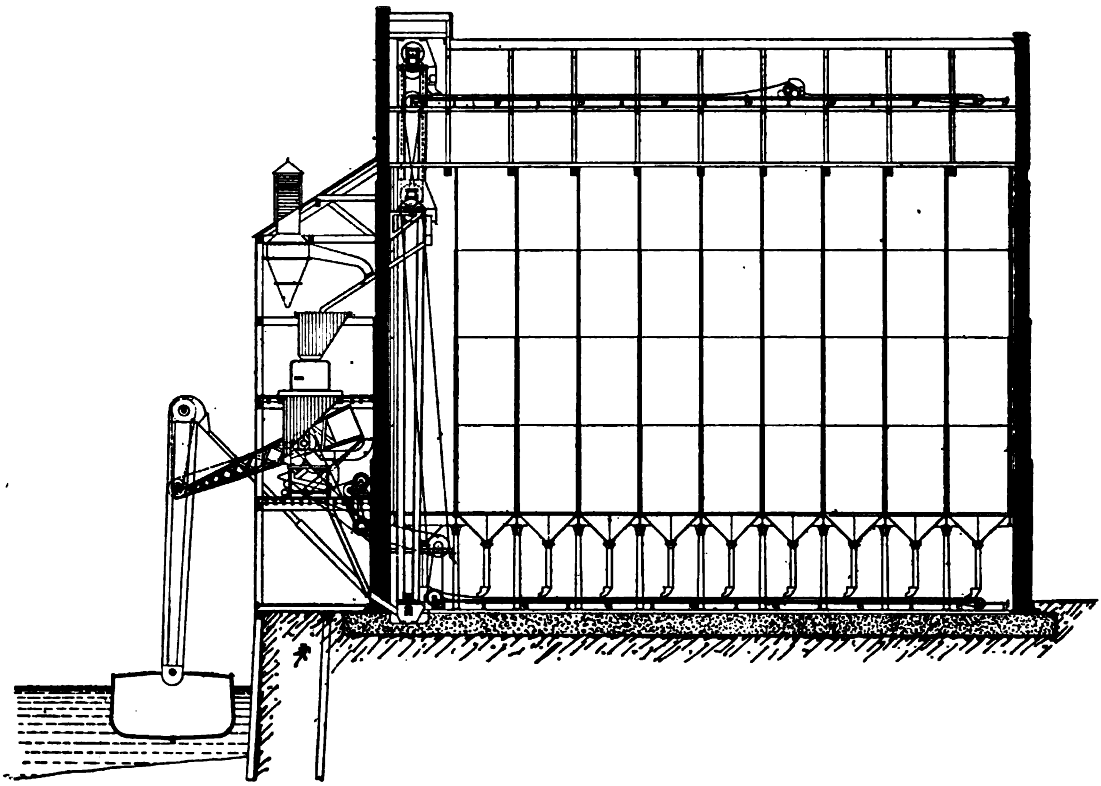

Fig. 506. A Typical Modern Granary.

LIST OF SOME OF THE PRINCIPAL GRANARIES IN GREAT BRITAIN.

Name of Owner and Title of Granary.	Material Used and Nature of Granary.	Capacity. Qrs.
Bristol Dock Co.—		
Avonmouth Dock Granary	Floor granaries	60,000
Portishead Dock Granary	" "	60,000
Princes Wharf Dock Granary	" "	70,000
Co-operative Wholesale Society Ltd.—		
Granary, Dunston-on-Tyne	Silos of ferro-concrete	42,000
Eagle Oil Mills Co.—		
Eagle Oil Mills and Bon Accord Mill Silos	Silos of wood with steel bottoms	33,133
East India Co.—		
Dock Granary	Silos of timber with steel bottoms	40,000
W. Gilyott & Co.'s Wilberforce Warehouses—		
No. 1. Garrison Side, Old Harbour, Hull	Floor warehouses	65,000
No. 2. High Street, Old Harbour	" "	20,000
No. 3. High Street, Old Harbour	" "	15,000
A. Guinness, Son, & Co. Ltd., Dublin—		
Malt Stores, St James' Gate Brewery	Silos of brick and concrete	125,000

Name of Owner and Title of Granary.	Material Used and Nature of Granary.	Capacity. Qrs.
Lancashire and Yorkshire Railway Co.—		
Silo Granary, Wyre Dock, Fleetwood	Silos of timber	150,000
Leith Grain Warehousing Co.—		
Patmore Elevator and Grain Silo	Silos of timber	125,000
Liverpool Grain Storage and Transit Co.—		
Nos. 1 and 2 Alexandra Grain Warehouses	Silos of brick	373,333
London and India Dock Co.—		
Royal Victoria Docks Silo	Silos of timber and steel	25,000
London and South-Western Railway Co.—		
Southampton Dock Granaries	Floor warehouses	304,000
Manchester Ship Canal Co.—		
Manchester Grain Silo	Silos of timber and brickwork	186,700
Mersey Dock and Harbour Board Floor and Silo Warehouses—		
Liverpool Dock Granary	Silos of brick and ferro-concrete	199,500
Birkenhead Granary	- - - - - - -	233,730
Millwall Dock Co.—		
Millwall Dock Granary	Floor and silo warehouse of brick	100,000
Oldham Roller Mills Granary	Silos of brick	23,778
Rishworth, Ingleby, & Lofthouse—		
Granary Swan Flour Mills, Hull	Silos of wood with iron hoppers	33,000
Sun Flour Mills Granary, Bromley-by-Bow	Silos of timber	32,013
Surrey Commercial Dock Co.'s Warehouses—		
North Side of Greenland Dock	Floor granaries, built of timber	82,000
North Side of South Dock	„ „ built of brick	141,000
South Side of South Dock	„ „ „ „	48,000
Transit Silos on the Thames	Silos of timber with concrete bottoms	32,000
W. Vernon & Co.—		
Silos at Mersey Docks	Hoppers of ferro-concrete	40,000
Victoria Dock Silos	„ „	56,000
Hurtley & Sons Ltd.—		
Wilmington Flour Mills, Hull	Silo warehouses	24,000
J. Rank—		
Rank's Grain Silos, Hull	Silo warehouses	20,000
		2,759,187

With regard to the much-discussed question of storage capacity for bread-stuffs in this country in case of war, the existing capacity might be taken from the above figures, which show the storage capacity of the larger British granaries, and allowing for the numerous smaller granaries, not mentioned here, the total capacity might be estimated as being approximately 10,000,000 qrs.

CHAPTER XXIX.

COAL STORES AND COAL SILOS.

THE only economical method of storing coal or minerals is in elevated silos or bins. This system has been adopted for many years, as far as grain and seeds are concerned, but it is only of comparatively recent years that it has been adopted for the storing of coal and minerals, more particularly on the Continent and in America.

Some establishments have found it expedient to erect extensive silo or bin systems for storing coal, and have equipped the same with complete mechanical plants.* Figs. 507 and 508 illustrate the coal store which has been used by Messrs Possehl & Co., Altona, since 1896.

This store was designed to receive coal coming by boat up the Elbe, screen it, and then despatch it either by rail for inland use, or by vehicular traffic for local consumption. Small coal is discharged from steamers by means of a ship's elevator of a capacity of 60 to 70 tons per hour, whilst large coal is unloaded by a crane and grab of a capacity of 40 to 50 tons per hour. The small coal which has been unloaded by the ship's elevator is stored in fifteen silos. These silos are hopper-bottomed, and the whole of their contents can therefore be withdrawn with a minimum of labour. Six of the fifteen silos are set apart for such coal as requires screening.

The main store contains six silos 69 feet in height, reaching down to the level of the ground, and nine silos of a height of 50 feet. The former measure 27 feet 6 inches by 21 feet 6 inches, and will contain 1,000 tons, whilst the latter have a floor area of 27 feet 6 inches by 28 feet 6 inches, and contain 800 tons. On the quay is a tower of iron construction which holds an elevator, and is connected with the main store by two iron gantries.

The ship elevator is suspended from one end of an iron derrick which is supported on the tower. The elevator discharges the coal on a band conveyor which has been erected within the derrick. This band in turn discharges its load on a second band running on the lower gantry, delivering into an automatic weighing machine, whence it slides down a shoot to the well of an inner elevator which takes it to the top of the building, and to another band conveyor which is provided with a throw-off carriage to the various silos.

A travelling crane, built by Messrs Nagel & Kaemp, of Hamburg, and driven by Siemens & Halske's electro-motors, is used for unloading the larger coal.

The ship elevator, derrick and gantry, with the conveyors, as well as the weighing machine-hopper, and elevator, are outside the main building, and are indicated in the illustration, Fig. 507, which also shows in dotted lines the position taken by the elevator

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* For installations of this class, but solely for feeding boilers, see "Coal-handling Plant for Gas-works, Power Stations, and Boiler-houses," pages 415-434.

[*To face page* 476.

when out of use. The elevator discharges its load into a band conveyor, which delivers into either of the six silos. Another band conveyor, which runs at right angles to the last one, communicates with the remaining silos.

On the ground floor is a movable automatic weighing machine that can be brought into contact with any of the silo outlets, the coal being thus automatically withdrawn and weighed at the same time. This refers to the nine silos only. The remaining six, for coal to be screened, extend to the ground, and are connected with two band conveyors. These deliver the coal to another elevator which takes it up to the top of the building, from which it is conveyed by a band to the screening appliances, and thence into a series of smaller silos ready for loading into vehicles.

The whole installation is driven by electricity, and when in full work only consumes 120 HP., which is generated by a vertical engine of 150 HP. coupled direct to the electro-

Fig. 508. Elevation of Coal Store, Altona.

motor. A similar engine, but of only 45 HP., is held in reserve for use when only a portion of the plant is required.

In these stores great care is taken to record the temperature at regular intervals, and thermometers enclosed in iron pipes are fixed in the different silos for this purpose. This is perhaps the best means of guarding against spontaneous combustion.

The large coal which is unloaded by a grab is never warehoused in the silos, but is either loaded into railway waggons or into small barges, the position of which is shown in Fig. 507.

This installation is the design of G. Luther, of Brunswick, by whom it was erected, and to whom the author is indebted for the description and illustrations given above.

In great ports like Hamburg, coal stores either on this or a similar system are absolutely necessary, and they are also becoming popular in all great industrial centres.

With regard to the storage of coal imported from England, which is not very liable to spontaneous combustion, the practice is to heap such coal up in the bin, or sometimes in little hillocks, 50 feet high or more. German coal, however, could not be dealt with in this way. The English Gas-works at Berlin make a practice in the winter of storing 60,000 tons of English coal in one uncovered yard, and no instance of spontaneous combustion is on record. On the other hand, German coal, which is used in the City Gas-works of Berlin and Charlottenburg, and also in the power-house of the Berlin Electric Co.'s Works, is stored in much thinner layers; but in spite of this precaution explosions have often taken place, and serious loss has occurred from this cause. Westphalian coal, on account of the high proportion of sulphur it contains, seems more exposed to this risk than Silesian coal. In each storehouse where German coal is kept in any quantity some precautions must be taken against fire risks.

The civic authorities of Berlin require gas-works provided with railway sidings to maintain in store 30 per cent. of one year's requirements, but works which are dependent for their supply on water and canal traffic are compelled to keep about 70 per cent. of a year's consumption in stock on account of the possibility of obstruction of the waterways by frost.

As land is very dear in cities, it is clear that instead of spreading such coal on the ground, or packing it away in covered sheds, it will be more profitable to store it in silos which can be filled to a great depth. But as the higher coal is stacked, the greater the risk of combustion, some means must evidently be adopted to guard against this danger. The following is the plan devised by Professor Buhle, town architect of Charlottenburg.*

To reduce the depth of the layer of coal, the silos are divided into two or more sections, placed one over the other. These sections are completely separated, and are filled, emptied, and aerated quite independently. The coal is brought by boat, and carried by a gravity bucket conveyor to the top of the silos, and may be passed as desired by a shoot to an upper bin, or by way of a second spout into a lower bin. The spouts are provided with slides which may be opened or closed for the purpose of filling either the upper or lower bins. The same spouts also serve to ventilate the lower bins.

Coal brought by rail or by waggon is carried by subterranean shoots provided with cut-off valves to the lower strand of the gravity bucket conveyor.

To lessen the danger of combustion it is perhaps above all things necessary to keep the height of the layer within certain limits, but another excellent means of combating this risk is to provide means of turning over the coal and clearing the bins whenever desirable.

The contents of the upper bins are discharged into railway trucks or carts and waggons by means of slides and shoots which are provided with valves, while the lower bins are discharged by a gravity bucket conveyor either direct or *viâ* the upper bins. For turning over the coal from the upper to the lower bins the slides communicating with the two may be used. The turning over, however, must not be repeated too often, on account of the breakage caused to the coal.

The temperature of the bins is exactly recorded from time to time by thermometers, which give the maximum temperature, the former being enclosed in iron pipes which descend into the coal.

The low cost at which the handling of the coal may be effected is of course the most essential feature in this system of storage. Another important point in this installation, in which it differs from any of its predecessors (including the 30,000-ton

* See *Zeitschrift des Vereines deutscher Ingenieure*, 9th July 1900.

store of the Danish Coal Co. of Copenhagen), is its accessibility from all sides. Except for the necessary gangways, which of course take up a little room, the whole of the stores have been utilised for storage purposes. When the upper bins have been cleared, they may gradually be filled from the lower, and this operation, carried out at a minimum of expense, has the undoubted advantage of aerating and cooling the coal.

CHAPTER XXX.

HIGH-LEVEL OR CANTILEVER CRANES.

PERHAPS one of the most important improvements that has been effected of late years in the mechanical handling of material is in connection with discharging ships to granaries and warehouses erected on or near the quay-side.

The first step in advance which superseded hand labour was taken when cranes were erected and used for the clearance of cargoes. At this stage it became the practice to fill coal in the ship into skips of cylindrical shape which were hoisted and then discharged through a hinged door into the trucks.

This system is indeed still in considerable use, but it has the disadvantage of calling for an inordinate amount of hand labour, and is therefore economically wasteful. An improvement on this method is the use of grabs which generally require a special kind of crane, and will effect a sensible saving in time. In later years the hoisting crane has been combined with a bridge or gantry which commands the whole length of the quay-side or store-yard. In or on these gantries mechanical means for conveying the material are erected, and every operation incidental to the reception and further handling of the material is effected by machinery. Such installations have been termed high-level cranes, and can be divided under two general heads :—

1. Elevated cranes in which the winding gear is mounted in a movable cabin, and accompanies the load from the ship to the point of delivery ; and

2. Cranes in which the winding gear is situated in a cabin fixed in the structure of the crane, and is connected by cables and chains to the running head which carries the load.

HIGH-LEVEL CRANES WITH MOVABLE WINDING GEARS.

These cranes are not so popular as those with fixed winding gears, probably for this reason, that the structure has to be erected on a more substantial scale, and is therefore more expensive. It has, however, several advantages, the principal one being that the handling of the material is better under control of the attendant as he accompanies the load in his cabin, which also contains the winding gear and motor.

Such cranes are numerous, but as they all bear a great resemblance to each other, it will suffice to give only a few examples.

High-level Crane Erected by J. Jaeger, of Duisburg.—Fig. 509 shows a crane of this type built by J. Jaeger, of Duisburg, Mannheim.

The crane is movable, and the carriage upon which it rests is supported by four wheels, and is propelled by a 20 HP. electro-motor running at 960 revolutions per minute. The speed of travel of the crane is about 1½ to 2 yards per second. To

prevent the crane from exceeding the limit of its track, buffer springs have been provided, not only on the crane structure, but also on the travelling trolley. Should the load exceed 7 tons, the trolley would tilt, and in order to prevent accidents, girders have been fixed across the base to reduce the tilting to a minimum. The lifting and turning motion of the crane is effected by a motor of 40 HP. running at 570 revolutions per minute. The grab which is used for unloading purposes can be suspended at any height, and has a capacity of 2 to $2\frac{1}{2}$ cubic yards. This grab has been built on Jaeger's system, and is described under the heading of "Grabs" (see pages 242-245). It is worked by double chains, and in order to allow the junction of the chains to pass the derrick head, this latter is fitted with three grooved sheaves to accommodate the chain when single,

Fig. 509. High-level Crane of J. Jaeger.

or when divided nearer the grab. The drums of the winding gear which manipulate the cranes are 20 inches diameter, whilst the winding rope is 1 inch. The discharge rope is about $\frac{3}{4}$ inch diameter. The speed of lifting the load from the ship is at the rate of about 1 foot 4 inches per second, and the maximum expenditure of power in working the crane at its highest speed is 38 HP., whilst the average expenditure of power is 27 HP.

The current which serves the electro-motor is an alternating one of 220 volts, which is conveyed to the machinery on the inland trestle away from the water-side, where it is received by seven contacts. The capacity of the crane is 40 tons per hour, but at a test twenty-six charges have been drawn from a ship with a total of 54 tons of coal.

Fig. 510 is a crane of similar construction erected by the same firm.

Electric Travelling Trolley of the Brown Hoisting Machinery Co.—A most important part in high-level cranes is the trolley with its motor. It can of course travel on any gantry or bridge of suitable construction.

Fig. 510. Example of High-level Crane.

Fig. 511 represents an electric travelling trolley. The illustration explains itself. This trolley is used to draw ore and limestone for blast-furnace purposes from the ore bins, and convey it to the furnace hoist, where the bottom door of the receptacle is opened and the ore discharged into the skip of the furnace hoist.

Electric Travelling Trolley of the Temperley Transporter Co.—Fig. 512 illustrates a travelling trolley fitted with a Hone grab. It is shown with its electro-motor, also the cable from which the current is taken. The illustration also shows the operator's seat, and the levers, by means of which the trolley as well as the grab are manipulated.

The capacity of the grab is 3 tons; it rises 50 feet per minute, and the trolley travels at a speed of from 400 to 500 feet per minute.

Fig. 511. Electric Travelling Trolley as used for Feeding Furnaces.

High-level Cranes with Fixed Winding Gears.

These undoubtedly owe their origin to American enterprise, and are largely used in the United States in a variety of forms.

This type of crane is similar in general operation to that in which the winch accompanies the load, but in the case of these particular cranes the structure need not be so substantial, as much smaller loads are dealt with, and in addition to the load, the weight of the traveller or running head only need be taken into account as against the weight of the movable cabin with the winch and motor.

But as this type of crane is sometimes built from 60 to 80 yards in length, the construction must be sufficiently firm to resist its own weight, and also the influence of high winds. There is also this advantage, that the velocity with which the load can be moved is greater than in the former case, where a much heavier load has to be handled; being from 12 to 14 feet per second, as against 5 to 6 feet per second in the former type.

American high-level cranes generally run at higher speeds than those usual in Europe; too great a speed is, however, not advisable, on account of the strain caused to the crane by the stopping and starting of the running loads.

The principal difficulty with high-level cranes with fixed winches is the complicated leading of the rope or ropes, and, in some constructions, the consequent great wear and tear on the ropes. The wear and tear is caused either by the ropes being bent in

two directions, or by their sometimes being led over small diameter guide pulleys, the former being necessary even with the simplest type.

The use of chains would obviate this difficulty; but these are unsuitable, not only on account of their weight, but also because they lack the elasticity of wire ropes, and are therefore more likely to break under the strain caused by the sudden stopping and starting, and also by the shocks occasioned by the use of grabs at the loading end of the crane. It is probably on this account that some firms prefer to fit their high-level cranes with ordinary skips instead of with mechanical grabs. With the latter the wear and tear on the ropes is certainly greater.

Instances have been known where wire ropes have had to be replaced after working

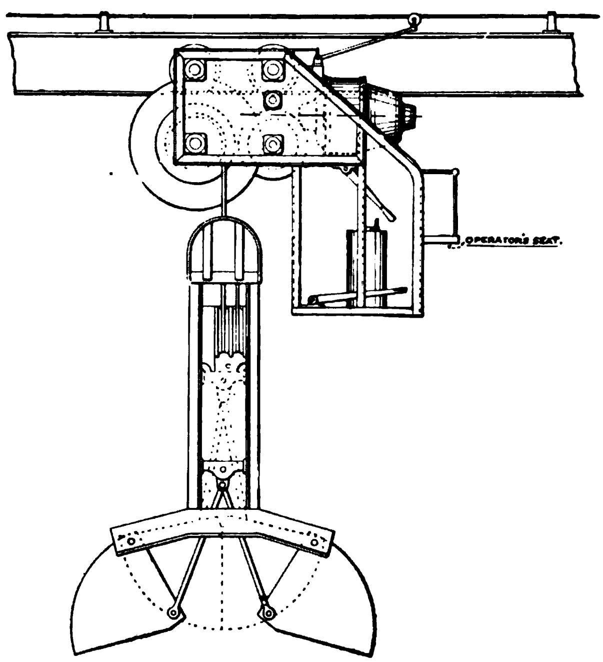


Fig. 512. Electric Travelling Trolley fitted with a Hone Grab.

only a few weeks. If grabs are used with cranes of this description it is best to use a one-rope grab, because a two-rope grab will complicate the handling of the plant.

Another difficulty in the use of high-level cranes with fixed winches arises from the fact that the man manipulating the winch cannot control the operations so well as if accompanying the load. It is therefore sometimes necessary to employ a signalman in a prominent position who can communicate between the men in the hold and the operator in the winch cabin. These minor disadvantages have, however, not materially checked the progress of this type of high-level crane, as their quicker unloading, easy manipulation, and smaller first cost have opened up a large field for them.

The following illustrations, Figs. 513 to 522, show, in rough diagrams, the most usual forms of manipulating the traveller, with its load, from the winch or winches. Cranes of this type are by no means new, but have been used for a number of years on a small scale on the principle shown in Fig. 513, where the rope which lifts the load is

fixed at one end of the structure, and at the other to the drum A, and supports the skip after passing over the fall block. If the position of the running head is changed by the drum B the load remains at the same distance from the ground. A represents the drum for raising and lowering the load, whilst B is the winch for moving it horizontally. The constant bending of the steel rope over the two pulleys on the traveller and over the fall block offers considerable resistance to the movement of the load, yet over short distances such cranes do satisfactory work. For long lengths and for a quick rate of travel this construction is unsuitable. It can, however, be used to advantage when the load is so held as to relieve the rope during the lateral movement of the running head, as shown in dotted lines, when the fall block is held in its topmost position by a catch suspended from the running head.

In such a position, and with the load supported by the head itself, the rope will bend freely and without much wear and tear during the horizontal movement of the load. The position of the load close to the running head is also an advantage, as it checks the swinging, pendulum fashion, and admits therefore of a quicker starting and stopping of the load. This means that the load must be raised to its fullest extent and locked before the horizontal movement can take place. It also entails a small loss of time for the locking and unlocking of the load in its raised position.

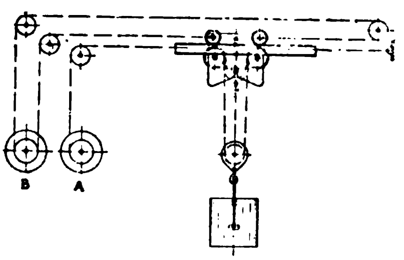


Fig. 513.

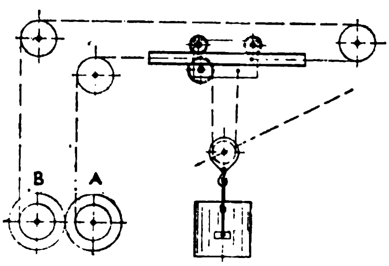


Fig. 514.

When ore or other material that does not deteriorate through a drop is being conveyed, it will be unnecessary to disengage the fall block, and lower the load down the pile before tipping the bucket.

Such difficulties as are met with in the plan shown in Fig. 513 are obviated in the scheme illustrated in Fig. 514. In this both conveying and elevating ropes are under the same tension. The two drums A and B are loose on their spindles, which are, however, coupled together by spur wheels, the drums being connected to the spindles by friction clutches, either separately or together. The drum A is for elevating only, but both drums A and B must be in motion when the running head is moved in either direction. This construction enables the operator by simply pulling the hauling ropes to raise or lower the loads in an oblique direction, as is indicated by the dotted line in Fig. 514. The angle is 2 : 1 to the horizontal. The side movement of the load is therefore twice as great as the up-and-down movement, but the proportion can be altered by using different fall blocks, or to meet cases where the motor speed varies according to the load. For short chains used in conjunction with a grab this oblique movement of the load is most convenient. The principal advantage of this construction is that the horizontal and vertical movements of the load are independent of each other, and that the traveller may be moved horizontally with the load in any position. For long cranes

and with high speeds it might be an advantage to convey the skip in as high a position as possible, so as to avoid the pendulum movement of the load. With this construction both winches A and B must be of the same power, as both ropes are under the same tension.

A similar construction is shown in Fig. 515. Both winches A and B can be turned either in the same or in opposite directions, this being accomplished by the use of a pair of wheels, of friction clutches, and of a third wheel C, which can be coupled between the two larger spur wheels. If both drums revolve in the same direction, they both wind up the rope, and thus elevate the load; whereas, in the other case, one drum winds up as much rope as the other unwinds, and the load is therefore conveyed in a horizontal direction.

In a scheme such as is illustrated in Fig. 516, the load is supported on an endless rope which is wound round the conveying drum B, and by means of this drum can be drawn either backward or forward. The drum A is for lifting and lowering the load by shortening or lengthening the endless rope which supports it, this being accomplished by a pair of jockey pulleys, as shown in the illustration.

The demand for high-level cranes with less complicated winding gear led to the

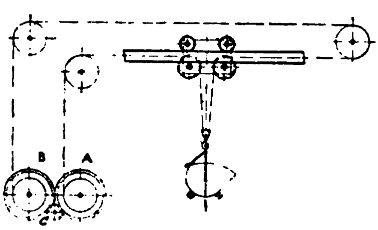


Fig. 515.

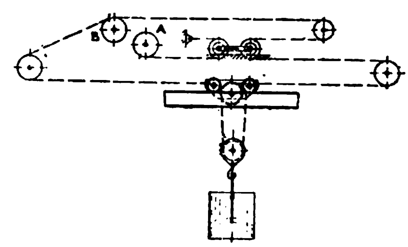


Fig. 516.

construction of cranes worked by one rope only. A crane of this type is illustrated in Fig. 517.

One end of the rope is attached to the winding drum of the winch and the other to the traveller. Supposing the winch to be standing, the load would descend by its own gravity and move the running head in an upward direction; but in order to prevent this, the traveller is secured to the girder upon which it runs by a catch and notches cut in the girder. As soon as the load has been raised to its topmost position, and the fall block has entered the running head as shown, it is retained there by a hook, which automatically releases the catches that locked the running head to the girder. On a further movement of the winding drum, the load proceeds in an upward direction, and when empty, the running head returns automatically down its own support. The crane is manipulated as follows:—The running head is pulled by the winch past one of the notches near which the unloading is to take place. The rope is then somewhat slackened so as to allow of a slight return of the traveller on its support, whereupon the catch will engage with one of the notches, and lock it in position. At the same time this releases the load, and by slackening the rope the load will be lowered.

In order to accelerate the return of the running head, the incline of the girder is placed at about 1 : 4. This is necessary, as the weight of the rope has to be drawn along with the head. If such an incline be prohibitive on account of local conditions, or if the crane be of sufficient length to cause the weight of the rope to hold the traveller

back, or to prevent it moving at a sufficient speed, a balance weight is used to accelerate the downward movement as shown.

Another and frequently used method, which is practical for working with one rope, is illustrated in Fig. 518.

The skip is here suspended from the fall block in the usual manner, and the supporting girder for the traveller is fixed at an angle of about 30 degrees, which angle is sufficient to prevent the running head with its load from moving upward when the winch is at a standstill. In fact, if the angle be made steeper, the load is inclined to run downwards, so that it is necessary to provide a stop block in order to prevent it from running too low. In the position shown, the load can be raised or lowered while the traveller remains stationary, but when raising the load beyond the topmost limit, so that it touches the traveller, the latter with its load will ascend the girder, and the load can then be discharged. The empty skip can only be lowered when the running head comes against an adjustable stop, as shown. The fact that this system requires such a very steep rail girder will account for its use being confined to comparatively short cranes, and to its mostly being used for unloading ships in connection with other methods of

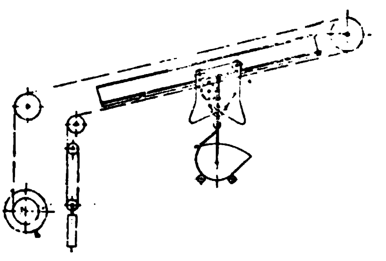


Fig. 517.

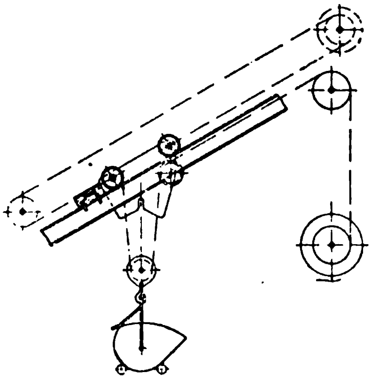


Fig. 518.

conveying, the high-level crane in this case only being used to transfer the material from the ship's hold to a conveyor which brings it to its destination ; whereas high-level cranes with level or slightly inclined rail girders are more generally used to convey the material from the ship to its final destination without the intervention of a second conveyor.

High-level Crane of the Brown Hoisting Machinery Co.—The high-level crane of the Brown Hoisting Machinery Co., Cleveland, Ohio, is one of a popular type. It is usually made so narrow that three or four can be placed close together to unload from the same ship, or at least one can be set to work over each hatchway. The general construction of the iron trussed bridge depends upon the span of the crane, but the supports are usually made in such a way that the cranes can be moved obliquely across the rails which carry them. Either the support on the quay or the inland support can be moved independently as circumstances may permit. This is accomplished by one support moving on a double track of rails whilst the other moves on a single track, both being connected with the bridge by a swivel joint which allows of this oblique position. The unloading is usually effected by means of a grab, which holds 1 to 2 cubic yards (for coal),

whilst ordinary skips are often used for unloading ore. The Brown Hoisting Machinery Co. have, however, a grab which is suitable for unloading iron ore, and which has been described under the heading of grabs. A weighing machine is sometimes fitted on the conveyor bridge, and by means of this each load can be weighed independently as it passes a certain portion of the track. Some of the earlier appliances of this firm were erected at one of Krupp's establishments; four of these cranes were erected on the Rhine near Duisburg, for unloading ore, which is the chief material imported. Each crane is driven by a 45 HP. electro-motor, running at a speed of 200 to 500 revolutions per minute. This has been geared by wheels in the proportion of 1 to 4·6 to the winding drum.

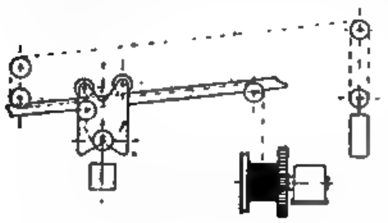


Fig. 519.

The manner in which the rope is connected from the winding drum to the traveller or running head is shown in Fig. 519, whilst Fig. 520 shows the details of the running head itself.

As long as the load is elevated, the running head is mechanically fixed, and is therefore prevented from following the direction of the hoisting rope. As soon as the load is lifted sufficiently high for the fall block to touch the traveller, the latter is uncoupled, and the load automatically held in that position, so that any further winding of the rope will move it in a more or less horizontal position. As soon as the load has been discharged, the traveller returns, its speed being controlled by a brake, until it has

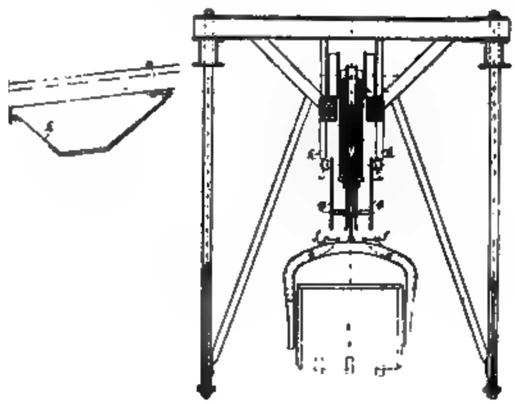


Fig. 520.

reached the point where it fixes itself, after which the further slackening of the rope will permit the descent of the skip. The inclines of the girder are in this case 1 in 8. This not being sufficient to allow of the traveller going back on its own account, a travelling rope with a balance weight had to be used for the return of the empty skip, as shown.

The running head is represented in Fig. 520 at the moment when it reaches the lowest point determined by the fixture a which enters into the space provided for it in lever b_1, and couples itself as shown in dotted lines as soon as the traveller reaches the end of its journey.

The lever b_2 is moved simultaneously, thus giving rod c a downward motion. This

action also moves lever *d*, which swivels round point *e* to the right at the top, and to the left at its lower end. This action releases the pulley and the fall block with the load. The skip is now descending, and whilst doing so the head or traveller is held in position by lever b_1. After the skip has been filled and raised, the projecting spindles of the fall block touch the forked end of rod *c*, which is thereby raised, so that *b*, b_1, and *d* are all replaced in their original position. Thereupon *a* is released by *b*, and lever *d* again holds the load, which, with the traveller, can proceed to the right. The skip is made to discharge its load automatically. It has a natural tendency to tip forward, but is prevented from tilting by the levers, which rest in grooves on the sides of the skip.

The running head is fitted with levers *gg*, which are held in position by springs in the tube *h*. One end of the lever is fitted with rollers *ii*. These rollers touch trippers *kk* which are fixed in the discharging position. Thus the levers *gg* will be lowered by the incline on trippers *kk* until they come in contact with levers *ff*, and release the skip, allowing it to discharge itself. This method of unloading is of course only used when minerals are being handled, as a fall from a height would in the case of coal be detrimental.

Fig. 520 also shows a cross section through the trestle bridge of the crane. The crane can be moved at the rate of 3 feet per second; whilst the movement of the

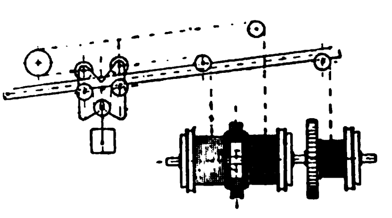


Fig. 521.

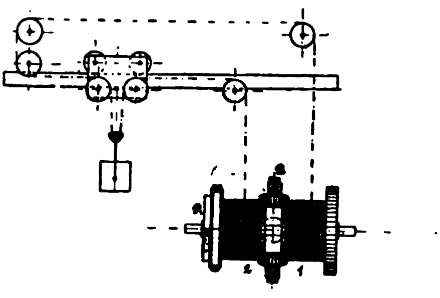


Fig. 522.

traveller is 13 and 20 feet per second when moving in an upward and downward direction respectively. The capacity of the crane is from 300 to 500 tons per day of ten hours, eight or more trimmers being employed to fill the skips.

The last of these four cranes was erected at a later date, and was fitted with all the latest improvements. The rope was guided as shown in Fig. 521, from which it will be seen that the lifting and conveying ropes are running on separate drums. The two winding drums are loose on the spindle, and are connected by two bevel wheels and four pinions. The four pinions are mounted in a ring which can be fixed or allowed to run loose. All drums are loose on the spindle, and can be coupled to it by friction clutches. This crane has the advantage of dispensing with the use of more or less complicated fixed stops. It can be stopped and unloaded at any point, and the skip need not be lifted to its topmost position before the traveller is put in motion, for if both conveying and lifting drums are started, the traveller with the skip will rise in an oblique direction, which movement can be utilised to fill the skip from a heap of material which lays at its natural angle of repose.

The winding gear with its rope connection, shown in Fig. 521, can also be modified in so far that the lifting drum can be dispensed with (see Fig. 522). Such a device is used by The C. W. Hunt Co., and also by the Brown Hoisting Machinery Co.

The ropes are in this case both run over the sheaves in the running head and secured to the suspender on which the skip hangs. The winding gear works as follows:—

The drum 1 is cast together with its driving wheel. It is keyed to the spindle, and can move in both directions. Drum 2 can be coupled to the spindle by the friction clutch R. Both drums receive and pay out rope on the same side, and are coupled together by gearing as shown in Fig. 521. The ring B in which the four bevel pinions are fixed, can be held by a band brake. If the load is to be elevated, both ropes are thrown in, the effect being that both drums revolve in the same direction, and as the four pinions are not fixed, they revolve freely, and are therefore out of action. The load can, by means of the band brake, either be held in suspension or lowered. If the traveller runs either forward or backward, the drums must revolve in opposite directions.

High-level Crane of the M'Myler Co.—High-level cranes similar to those previously described have been built by the M'Myler Co., of Cleveland and London, the

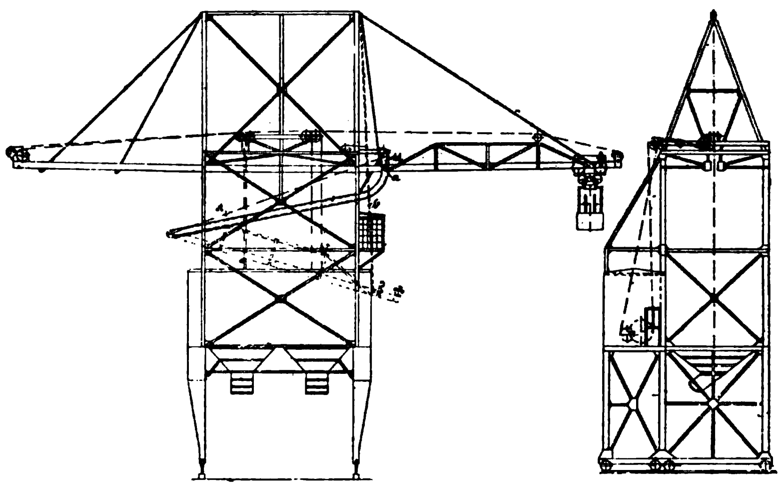


Fig. 523. High-Level Crane of the M'Myler Co.

difference being that the track of the traveller is fixed on a lower instead of a higher level.

Fig. 523 shows a small installation erected by this firm for the purpose of conveying the material from the ship to the railway truck. This installation is of interest chiefly on account of the unusual way in which the jib end of the crane is disposed of when the latter is out of use. These ends are, as a rule, raised up out of the way, but in this case the end is lowered beneath the main structure into the position shown in dotted lines.

This is accomplished by means of rope *d*. The rollers *a* which are at the extremity of the jib end, move in the groove formed by two channel irons, which are bolted to the structure, the rope *b* remaining unaltered. The rope is guided in a similar manner to that shown in Fig. 521, but as this crane works in conjunction with a two-rope grab, an additional rope is employed for the opening of the grab. Such installations are successfully at work on the Providence River, Indiana, U.S.A.

High-level Cranes Erected for Messrs Jones & Adams, West Superior, U.S.A.—This installation is illustrated in Fig. 524, which gives plan and elevation of

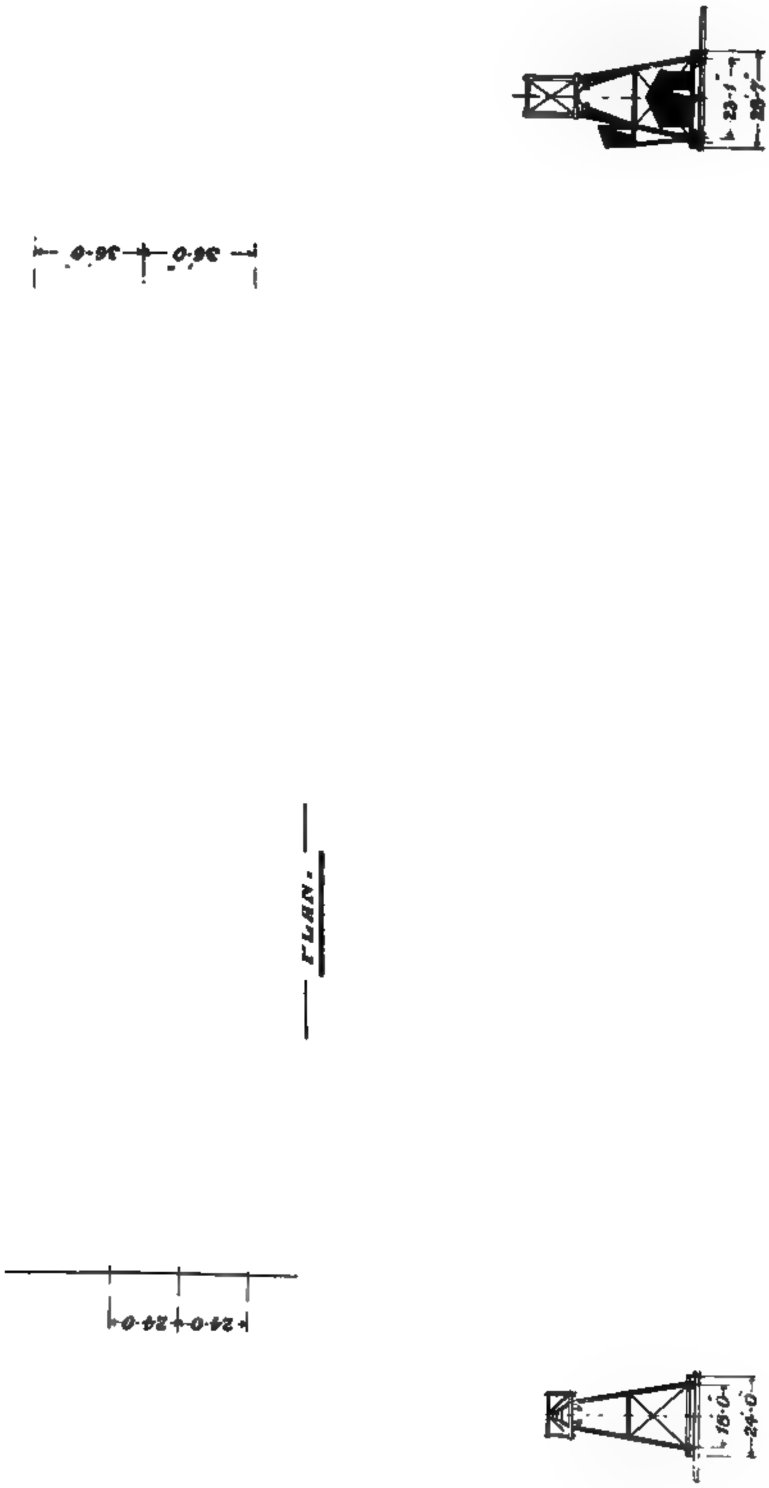


Fig. 524. Plan and Elevation of High-level Crane Erected for Messrs Jones & Adams, West Superior, U.S.A.

the crane; it consists of three Brown bridge tramway cranes operated by electric power. The three cranes are shown running side by side on the same lines of rails.

Fig. 525. High-level Crane by Bleichert.

These cranes are used for unloading coal from vessels and conveying it to stock piles or into railway trucks. At a recent test it was found that the capacity of three of these cranes was about 2,500 tons of coal in ten hours. The average capacity is, however, 60 tons per crane per hour, or one trip per minute.

The grab used was one of a capacity of 1 ton, and the test was made with Hocking coal, which is one of the most lumpy coals in the United States, and more resembles Scotch coal. When the test was made, every bucket of coal was carried from the front of the quay to a distance of about 150 feet before the grab was allowed to discharge.

The illustration almost explains itself. The crane is manipulated from a machinery house which has a driver's cabin above The whole crane can move backward and forward along the quay-side over the three lines of rails shown. The grab is lowered into the hold, and when full, raised again, and the coal or other material is brought over the stock pile or over railway trucks, where the grab is opened to discharge its load.

The same installation can of course be used to take the material from the stock pile with the grab, and discharge it into either railway trucks, or into vessels at the quay-side.

This installation was also erected by the Brown Hoisting Machinery Co.

Bleichert's High-level Cranes.—The crane illustrated in Fig. 525 consists essentially of a bridge girder B with two extensions A and A^1, and two trestles P and S both mounted on wheels. The bridge or gantry is designed for the sole purpose of supporting the running head with its load. The main support S, which also encloses the motor-house, rests on two lines of rails. The trestle P on the quay-side is very light

in comparison with the main support, and is so coupled to the gantry that it gives sufficiently to make allowance for any extension or contraction of the bridge through a change in the temperature. The extension A is so hinged that it can be moved out of the way of the ship's tackle if necessary. This is shown in dotted lines. It can be raised by means of the small winch W, and lowered by its own weight and by the use of a brake. The skip, which runs the whole length of the gantry, can be unloaded either into a stock heap or into railway trucks, as may be seen from the illustration. Two independent ropes are used for the manipulation of the crane, the one for lifting and the other for conveying. The action is as follows :—

The skip, after being filled in the ship's hold, is raised to its fullest extent, so that the fall block engages with the running head, whereupon the lifting rope has no further load to carry. The conveying rope is then brought into action, and the running head with its load is brought to the discharging point and there tipped. As the whole appliance is mounted on wheels, it can be moved forward or backward so as to entirely discharge the ship without altering its position. The operator's cabin, marked H in the illustration, is so placed as to give a good view of the unloading operations.

The time occupied by one skip in travelling from and returning to the ship is about one minute. The contents of the skip weigh $1\frac{1}{2}$ tons. In order to avoid any loss of time several skips are always in use. The average capacity is 500 tons in ten hours. This of course depends very much on the number of trimmers who fill the skips and the nature of the material to be unloaded. It would be materially increased if a grab were used instead of the ordinary skip.

Fig. 526 also illustrates a crane designed by Bleichert which is similar to the one already described, but is much shorter, being only used for unloading ships into railway trucks. The bridge or gantry AA is supported by two uprights P at a sufficient distance apart to allow room for two lines of rails. The steam engine and boiler are shown in the illustration, and their weight gives additional stability to the structure. The jib end of the bridge can be raised in a similar manner to that of the crane previously described, and the action of the machine is very similar. The capacity of any of these high-level cranes can be doubled by having two sets of rails for two running heads on the same gantry.

The Temperley Transporter.—In conveying coal, grain, and other heavy goods, the Temperley transporter has undoubtedly rendered excellent service. It is a type of high-level crane, and is used for the delivery of coal from lighters or barges, as well as from large vessels lying at wharves, into boiler-houses, while it has also been found most useful for the loading and unloading of grain vessels.

This appliance is so largely used that it is worthy of a full description. Mr Joseph Temperley, the inventor, had for many years been engaged in the shipping industry in London, and had observed the inadequacy of old-fashioned methods of discharging vessels in the port of London. His invention dates from about the year 1892, when turret ships and whalebacks first made their appearance. The original Temperley transporter consisted essentially of a long I-shaped section beam with a traveller running on the lower flange. The beam was triced up to the movable framework or shear-legs, whilst the traveller was worked by two ropes engaging on the two drums of a double-barrelled winch. The apparatus was so arranged as to command the hold of a vessel and a point from 20 to 30 feet overboard. This was the earliest type of Temperley transporter, but the inventor was not altogether satisfied with his work, as the apparatus appeared to him rather too complicated for general use. Apparently some difficulty was experienced in instructing ordinary river-side labourers in the use of the double winch. He accordingly simplified

the gear, so that his appliance could be used with an ordinary ship's winch on which a single rope is paid out or hauled in.

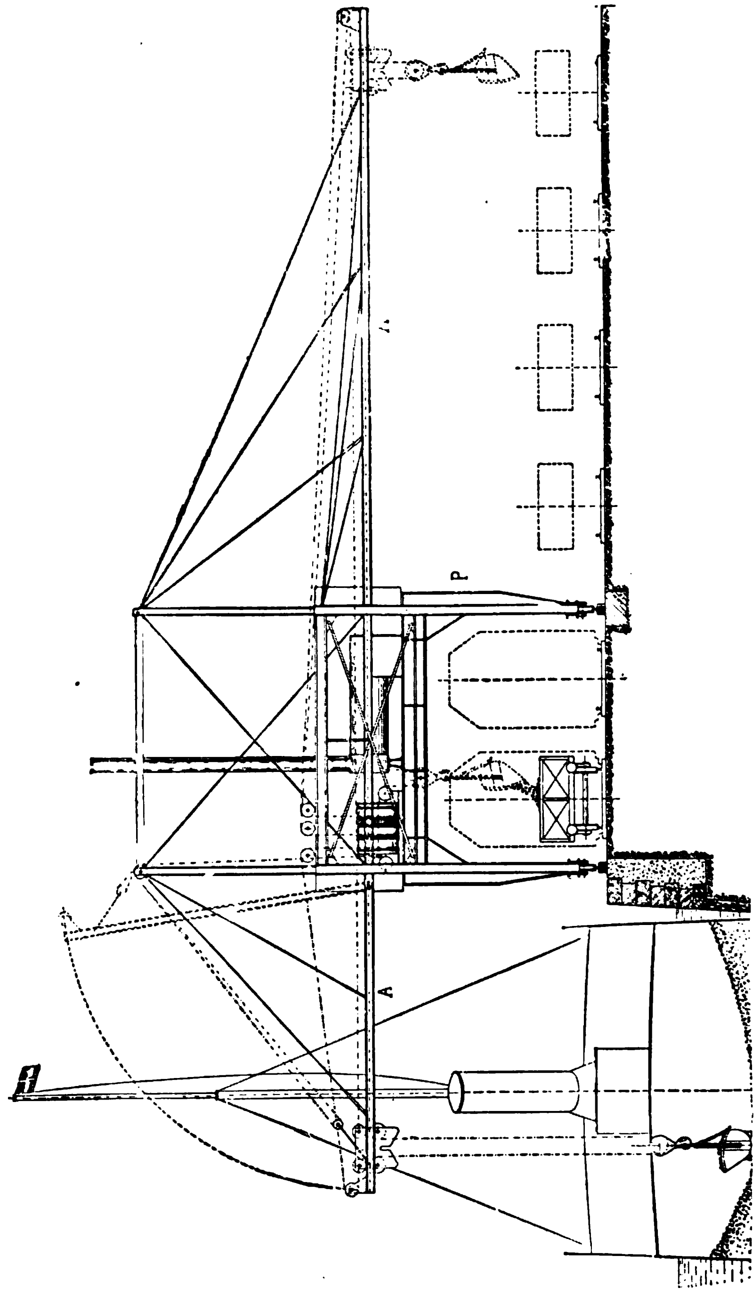


Fig. 526. High-level Crane by Bleichert.

In the perfected transporter the running head or traveller is fitted with an ingenious automatic device, by means of which the traveller may be arrested and held stationary while the load is being either lifted or lowered. This device also keeps the load in

suspension while the traveller is moving. The British Admiralty and many foreign Governments have adopted and successfully applied the conveyor to the rather difficult task of coaling warships.

Temperley transporters are used under a great variety of conditions, both in the portable and fixed type on staging, or on gantries, at inland points, as much as, and perhaps more than, for harbour work. The original length of track of 40 to 50 feet or so has now been extended to ten or even twenty times as much, whilst the speed of lifting and travelling, which, in the early days, was about 150 feet per minute, is now raised to a speed of 1,400 feet per minute. It was of course inevitable that this great increase of speed should necessitate the use of better winding gear, and the simple winch which was originally used is quite inadequate for these modern high-speed installations. The Temperley transporter consists of three principal parts, namely, of a steel beam of I-section, which may be hung from the ship's mast or derrick, in which case it would vary in length from 30 to 65 feet, or as an alternative it may be supported on shore by an iron-work trestle frame, in which case the length of the track may be considerably extended; secondly, of an automatic traveller; and thirdly, of a winch which operates the traveller by means of a wire cable.

Assuming this transporter were being used on board a ship, it would be attached by wire slings to the end of an ordinary derrick, and would then be held up and secured by guy ropes in an inclined position across the vessel so as to command both the hatchways and the quay, or any lighters or barges which might be alongside. The pulley end of the I-shaped beam should be higher than the other end, towards which the movement of the traveller is effected by gravity. The angle at which the beam is inclined may be varied to suit the precise nature of the work. The beam may project over either side of the vessel. It remains in a fixed position, and should be quite rigid when at work, except that it should be free to swing laterally on its swivels. A steel wire rope is passed over the sheave of the traveller and runs over the fixed pulley at the end of the beam, and over two leading blocks, one being placed at the head and the other at the heel of the derrick. This wire rope is attached to the drum of an ordinary steam winch which is placed on the deck of the vessel. The automatic catch serves to stop the traveller while the load is being lifted or lowered, and also to sustain the load as the traveller moves along the beam.

The load can be discharged at any number of fixed points on the length of the beam. Such points or stops are usually placed about 5 feet apart, all these operations being under the control of the attendant.

The traveller or running head consists essentially of the following parts:—

Two side frames bolted together with four wheels for travelling along the beam.

Large sheaves for the lifting rope mounted on the same pin as the suspender.

Fall block for holding the load while the traveller is moving.

Pawl to prevent the premature lifting of the fall block.

Guard to keep the bell on the fall-block hook as the traveller is in motion.

Double cam for locking the traveller to the beam as the load is being lifted and lowered.

Single cam (interlocking with double cam) for securing fall block when carrying load.

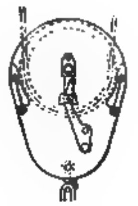
Sliding bolt passing through slots in the cams and frames for alternately locking the cams.

Toggle to cant the tooth of double cam in the stops on the beam.

Check plate to prevent the movement of the single cam when lifting and lowering.

Two positions of the traveller are shown in Figs. 527 and 528. In Fig. 527 the fall

block is "home" in the traveller, and the latter is unlocked from the beam on which it runs, and can be drawn along the transporter beam, the load during its travel being supported from the hook marked K in the figure. Should, however, the hauling rope be paid out instead of being hauled in, pawl A catches on the notch, causing block B to rotate on its pivot, and its projecting tooth to engage in the large notch shown. The weight of the traveller tending to make it slide down the beam causes block B to move round into the position shown in Fig. 528. One end of this block is connected to a system of links lettered C, D, E, F. In Fig. 527 the links D and E are nearly in a straight line, and thus the weight of the fall block, which is in position, as shown by the link FG, exerts little pressure on block B. What little pressure there is tends to keep B against its stop in the position there shown. Referring to Fig. 528, the tooth on B engages with a notch, and by means of link C pulls the two links D and E into the position shown in Fig. 528. The link then descends, being helped by its own weight, and also by the weight of the fall block. The hook is provided with a cam slot shown



Figs. 527 and 528. Showing Sliding Block and Traveller of Temperley Transporter.

at H, in which engages a fixed pin. This cam slot is of such a shape that as the hook K descends it is swung to the left, as shown in Fig. 528, thus releasing the fall block, which, on paying out the lifting rope, descends freely. On raising the block again, striking pieces on it will come in contact with hook K, and raising the latter, will force up link F. The latter, by means of link E, will then pull over links C and D from the position shown in Fig. 528 into the position shown in Fig. 527, thus unlocking the traveller, and at the same time hook K comes again into position to suspend the load, as in Fig. 527. That is to say, the conditions of Fig. 527 are restored, except that the small pawl A now slopes up to the left instead of to the right, as there shown. It therefore follows that on slackening the rope, this pawl no longer catches on the beam, and the traveller is free to run down the latter on paying out the hauling rope. Generally the traveller is, in these circumstances, allowed to run to the very end of the beam, where a projecting block of metal catches the tooth on the block B, which thus locks itself without any assistance from the small pawl, but the traveller can also be brought to rest at any intermediate point.

The mechanism for dumping, described below, is in reality the only gear which can properly be called automatic. Position A, Fig. 529, shows the dumping mechanism when the loaded skip is being lifted, the dumping mechanism of the fall block having been thrown completely out of gear by the setting lever being placed in the position in which it is shown.

On the fall block entering the traveller, the dumping mechanism is brought into the relations shown in position B, by the point of the sustaining hooks 31 throwing the setting lever 37 into the position shown in this diagram. In this position the load is carried either up or down.

On the traveller engaging with a stop on the beam at the point at which it is desired that the load should be lowered, the fall block is released from the traveller, and the position of the dumping mechanism is altered to that shown in position C, Fig. 529. It will be observed that the dumping toggle 47 has been turned over, and is pointing in the opposite direction.

With the mechanism in this position the skip is lowered to the point at which it is desired to discharge its contents.

On commencing to lift, the dumping toggle 47 engages with the notch 34 on the periphery of the fall-block sheave, and by the continued movement of the sheave the latch of the skip is pulled out of gear by the wiper and wiper chain 58 and 59 acting through the lever 64 and the chain 65 attached to the latch of the skip.

A special feature of the dumping fall block is the setting lever 37, by means of which the dumping mechanism is thrown entirely out of gear, so that by no possibility can the skip be automatically upset while being lifted from the weighing machine. If the men omit to throw the dumping mechanism out of action by the movement of the setting lever, the bucket immediately upsets on the commencement of lifting. Thus the operators, although they cannot be hurt by the upsetting of the bucket, are forcibly reminded of the results of their negligence.

It may be observed that when one cam is locked the other is always free. When free the double cam is actuated by contact with stops on the beam, and the single cam is actuated by the movement of the fall block. The slides in the cams are so designed that the movement of the free cam causes the release of the locked cam, whilst the release of the one effects the locking of the other. This reciprocating action of the cam automatically and simultaneously arrests the traveller and releases the load, or releases the traveller and secures the load.

When the traveller is locked to the beam as shown in Fig. 528, lifting or lowering is accomplished by hauling in or paying out the rope in the ordinary way. If it be desired to release the traveller, the operator has only to haul in the rope until the bell has lifted the pawl lever and entered the hook of the fall block, when the latter in turning will cause the cams of the traveller to revolve until they come into the position in Fig. 527 where the traveller is free. If it be desired to cause the traveller to move up the beam, the operator has only to continue to haul in the rope until the front part of the traveller has passed the point at which it is desired to lower, when by a reversal of the winch the traveller will engage with the stops and the load will be lowered. If the traveller is to descend the beam, the operator has but to release the stop, reverse the winch and pay out rope, and the traveller will pass to the intermediate stops because the toggle has not been cocked, and is therefore inoperative. The arresting of the traveller at the intermediate stop when moving down the beam is a very simple matter. It is only necessary to allow the carriage to pass the stop, when by drawing it back in an upward direction, the toggle will become cocked, after which, as the rope is again paid

out, the traveller will engage with a stop, and the load be lowered at that point. As the traveller moves up or down the track, the cam tooth can pass a stop with a clearance, but as the cam reaches the bottom stop it will, without the cocking of the toggle, automatically

Fig. 529. Showing Various Positions of Running Head and Skip in Temperley Transporter.

engage with it, and as the rope is paid out, the load will automatically be lowered. Lately these transporters have been fitted with one or two rope mechanical grabs.

Temperley Transporter at the Deptford Station of the London Electric Supply Corporation.—This is a very large installation of the Temperley transporter.

It consists in the main of an inclined beam about 400 feet long, which is supported by two steel towers and four steel A-frames from which a comprehensive system of steel supporting ropes is carried.

The towers are very high, as it is essential that large quantities of coal should be deposited on the floors above the boiler-rooms, which constitute the main bunkerage of the station. A considerable amount can also be stored underneath the transporter on the ground of the wharf and quite clear of the main buildings. The front of the wharf is provided with a couple of suitable hoppers into which coal is dropped from a pair of grabs worked by two travelling cranes.

Coal can be taken from two barges, one lying along the front of the wharf, while the other is moored in a small dock-side at right angles. The cranes drop their grabs on to the coal in the barges, and then haul away, raising about $1\frac{1}{4}$ tons of coal at each lift. When sufficiently high, the cranes are slewed round, and the grab discharged into the skip of the transporter.

Temperley Transporter at the Vizcaya Works, Bilbao.—A typical installation of the Temperley transporter may be seen at the Vizcaya Works, Bilbao, in Spain, where it is used for discharging coal to be converted into coke for the blast furnaces. This transporter is of the travelling tower type. The transporter beam is provided, as usual, with stops or notches at intervals of 5 feet throughout its entire length, and the load may be lifted or lowered at any one of these points as may be desired. The following is the method of operation:—As soon as the loaded skip has been attached to the lifting hook, the engine is started, and the load lifted at full speed (about 300 feet per minute), until the fall block approaches the bell of the traveller, when it becomes necessary to slow down in order to turn the corner gently. As soon as the fall block has entered the bell of the traveller, it engages with hooks, and the lines are released. The traveller simultaneously becomes released from the beam, and draws the transporter at a speed of 700 to 800 feet per minute along the transporter beam. On reaching the point at which it is desired to lower the load, the driver stops his engine and throws the hoisting drum out of gear. Thereupon the traveller commences to run down the beam and automatically engages with the first stop it meets. The engagement with the stop fixes the traveller to the transporter beam, and simultaneously releases the fall block from the bell of the traveller. By continuing to pay out rope, the skip and its contents are lowered by the brake, until it is a foot or two from the ground or at the top of the stock heap. Then, on commencing to lift, the bucket will automatically discharge its contents. Lifting continues until the fall block again enters the bell of the traveller, which is disengaged from the beam as the fall block locks with it. As the driver reverses the engine, the traveller with the empty skip runs down the beam under the control of the brake at a speed of from 800 to 1,000 feet per minute. On reaching the bottom stop over the vessel, the traveller automatically engages and releases the fall block, the driver continuing to pay out rope until the skip has reached the bottom of the vessel.

It is stated that the operation of lifting the loaded skip from the vessel, transporting it to a distance of 170 feet, lowering it to the ground, emptying it and returning it to the vessel for another load, can be performed in one minute.

This transporter will carry loads of $1\frac{1}{2}$ tons, while the stability of the tower is sufficient, without rail clips or blocking, to admit of this load being lowered with great rapidity and brought smartly to rest. Thus the installation may be moved in any direction according as it may be desired to take coal from different parts of the vessels'

hatchways, or to deposit at various points on the stock heap. The engines supply enough power for lifting the full load of $1\frac{1}{2}$ tons at a speed of 300 feet per minute, and of moving the load along the I-shaped beam at a speed of 600 to 800 feet per minute.

The engines also supply power to special machinery for raising and lowering the hinged arm of the transporter which projects over the vessel, and for moving the tower along the rollers in either direction. The hoisting drum runs loose on the shaft for lowering, and is put into gear for hoisting by means of a friction cone of large diameter.

Fig. 530. Temperley Coal "Haulabout."

As the engine is not fitted with reversing gear, the wear and tear of ordinary link action is avoided. The operator drives the engine from a platform which gives him a clear view over the stock heap into the vessel which is being cleared.

The Temperley Coal "Haulabout."—Fig. 530 shows a Temperley coal "haulabout" of 1,000 tons capacity used by the British Admiralty for taking in coal at Portsmouth. The hulls of these "haulabouts" are plain steel barges with hatchways extending nearly across the vessel. Each vessel is equipped with two self-contained Temperley travelling tower transporters, the beams of which have a very long overreach

on either side, and are high enough to take coal from a large collier and deliver it direct on the boat deck of the largest battleships or cruisers. The towers are made to travel the full length of the vessel, and command the entire hold both for filling and discharging purposes. They are also fitted with appliances for mechanically hoisting and conveying the load, raising and lowering the overhanging parts of the beams, and propelling the tower along the rails, as well as removing and replacing the hatch covers. The principal purposes for which these craft have been built are to provide a coaling vessel of considerable storage capacity, capable of being hauled about from vessel to vessel, where it can either supply coal from its hold, or be used for discharging coal direct from the collier to the vessel to be coaled. The "haulabouts" are capable of filling their own holds either from colliers or from the shore, for which purpose they are fitted with automatic dumping buckets.

The utility of these "haulabouts" has led to the building of Floating Coal Depots on similar lines, and one of these, of 12,000 tons capacity and equipped with twelve Temperley transporters, has recently been acquired by the British Admiralty.

Temperley Transporter at Delagoa Bay Harbour.—Amongst the more modern installations is the transporter supplied to the Portuguese Government for the transit sheds at Delagoa Bay Harbour. This plant is illustrated in Fig. 531. There are four travelling tower transporters mounted on rails, the jib ends of which can be raised out of the way as shown in dotted lines, so as to clear the rigging of the ships to be unloaded. The towers are of the raised platform type, so as to allow of the railway trucks passing underneath. In addition to these four, there are thirty-six fixed transporter beams acting as continuations, twelve in each shed, and spaced between 16 and 17 feet apart. These are shown in dotted lines. Thus the transporters can be coupled to any one of the continuations, and unload the ships into trucks on the quay, or into the sheds. The front view shows the open bonnets in the roof which afford a passage for the traveller.

The cranes are designed for a maximum load of 2 tons, for a speed of lift of 250 feet per minute, and a speed of travel along the beam of 820 feet per minute.

Temperley Transporter at the West Middlesex Water-works.—The West Middlesex Water-works, Hammersmith, have also a modern installation of this type for unloading coal. It is illustrated in Fig. 532, and consists of a fixed transporter for loads of 30 cwt., lifting at the rate of 150 feet per minute, and transporting along the beam at a speed of 800 feet per minute, the total length of the beam being 328 feet. The travelling transporter is for the same load and speed, and the total length of the beam is 100 feet. The fixed transporter takes its loads from the barges and conveys them above a public footpath and two boiler-houses, and delivers either to these boiler-houses or to the store-yard beyond. The travelling transporter can command the whole length of the yard, and is also used for bringing the coal to the fixed transporter which conveys it to the boiler-houses.

Temperley Transporter at West Ham Electric Station. — Fig. 533 shows a similar installation for the West Ham Electric Generating Station. It conveys the coal from the canal to the bunkers over the boilers. The length of this conveyor, which has a capacity of 2 tons, is 298 feet. The height of the lift is 45 feet, and the length of beam 315 feet.

Temperley Transporter at Woolwich Arsenal.—An illustration of this interesting installation is given in Figs. 534 and 535, the latter being a photographic view. One of the cranes is shown with its jib end extended in working position, whilst the other is shown with its jib end moved out of the way.

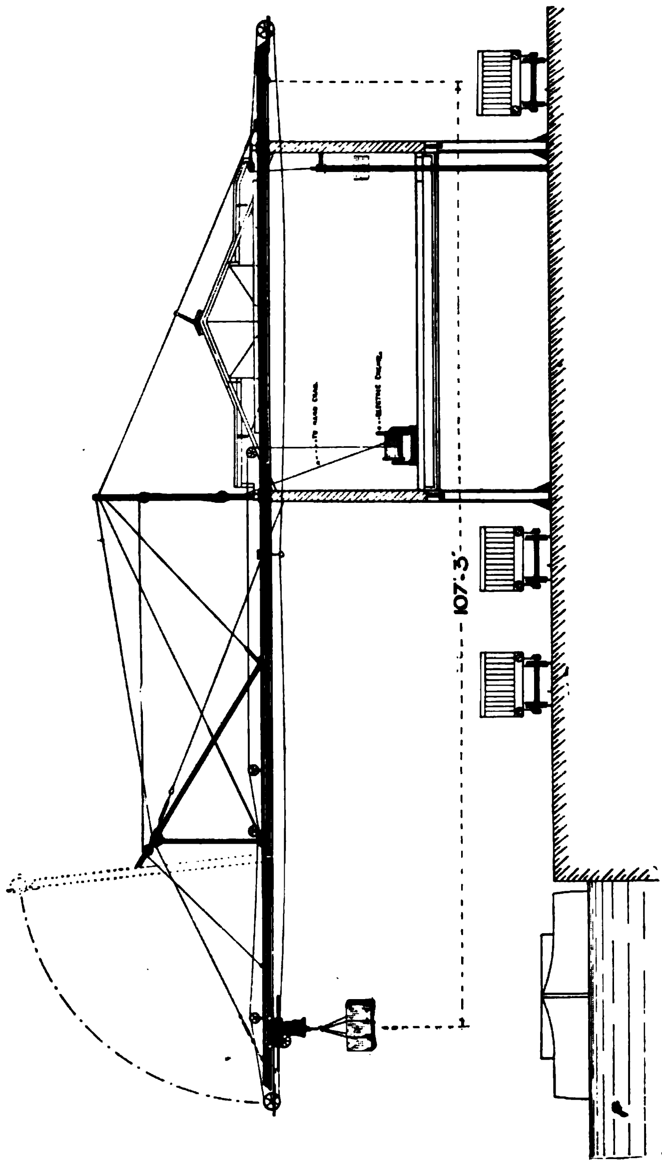


Fig. 534. Cross Section of Stores at the Royal Arsenal, Woolwich, showing Transporter for the Storing and Shipping of War Material.

These transporters command a range of travel of 170 feet, and are for loads of 1½ tons. They are used for shipping military stores at the Royal Arsenal.

Ore-unloading Plant at the "Kraft" Iron-works, near Stettin, Germany.—An interesting example of an ore-unloading plant is that erected at the "Kraft" Iron-works, near Stettin, Germany, by Pohlig, of Cologne, which is illustrated in Fig. 536.

The installation consists of five movable high-level cranes in conjunction with five automatic "Hunt" railways. It is used for unloading coal and ore out of sea-going vessels and depositing it in the extensive store-yard. These cranes are fitted with movable jib ends of 30 feet extension, so that they can be moved out of the way of the ship's tackle.

The five "Hunt" railways are rather more than 200 feet in length. The plant is driven by electro-motors and an alternating current of 450 volts. Each of the five installations can be moved independently on rails, as shown in the illustration, at a

Fig. 535. Temperley Fixed Transporters for Storing and Shipping Military Stores at the Royal Arsenal, Woolwich.

speed of about 40 feet per minute. The capacity of each of the five cranes is 40 tons of coal, or about 50 tons of ore.

The towers at the quay-side contain hoppers into which the material is unloaded, so that it can be weighed prior to its discharge by the "Hunt" railway. Four of the cranes were put up in 1898, whilst the fifth was erected in 1900.

High-level Crane at the Elektron Chemical Works, Griesheim a. M., Germany.—This is shown in Fig. 537, and is worked in connection with a ropeway.

The winch is a fixed one, and the running head works in conjunction with a grab. The inclined track upon which the running head ascends and descends is sufficiently

Fig. 536. Ore-unloading Plant at the "Kraft" Iron-works, Stettin.

curved to allow of the grab and running head descending by their own gravity when empty.

The grab is discharged into a hopper, which is a portion of the terminal tower, and

the ropeway buckets are filled from this. The ropeway itself has a length of 765 yards, and the whole plant has a capacity of 80 tons per hour.

This installation was erected by Pohlig, of Cologne.

High-level Crane Erected at a Gas-works, Berlin.—A high-level crane and a steel band conveyor for use at a gas-works in Berlin are illustrated in Fig. 538.

This plant was also built by Pohlig, and consists of the ordinary type of "Hunt" crane already described, which is utilised in conjunction with a grab. The coal, after being unloaded from the barge, is deposited into a hopper, from which it is admitted to the steel band conveyor, which takes it to the gas-works.

Fig. 537. High-level Crane at the Elektron Chemical Works, Elektron.

"Hunt" Conveyor for Conveying Small Coal in connection with a Coal-washing Plant. Fig. 539 represents a series of overhead silos which are fed by a "Hunt" conveyor, the installation being used in connection with a coal-washing plant at the Durdweiler Colliery, Germany. The capacity of the conveying plant is 120 tons of coal per hour. The illustration shows four outlets from silos whence the coal can be withdrawn into special railway trucks. This installation was also erected by Pohlig.

High-level Crane at the Copenhagen Gas-works.—Fig. 540 shows a similar installation at the Copenhagen Gas-works.

High-level Cranes at the Coal Store of the Danish Coal Co., Copenhagen. Fig. 541 shows yet another similar installation for the Danish Coal Co.'s Store at Copenhagen,* in which may be seen five cranes of this type which unload the coal for storage purposes.

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* See also page 479.

Fig. 538. High-level Crane at a Gas-works, Berlin.

Fig. 540 High-level Crane at the Copenhagen Gas-works.

Fig. 541. Coal-unloading Plant of the Danish Coal Co., Copenhagen.

High-level Cranes of the Zürich Gas-works.—Fig. 542 shows a similar installation erected by the same firm, in which three cranes are working side by side. This is the coal-receiving installation for the Gas-works, Zurich, Switzerland. After the coal has been received by these cranes, it is deposited in the cars of the "Hunt" automatic railway. One of these is shown in the illustration just starting on its journey to the coal store.

Fig. 542. Coal-unloading Plant in connection with Hunt's Automatic Railway at the Zürich Gas-works.

High-level Crane of the C. W. Hunt Co.—A high-level crane of the most recent and improved type is that designed by Messrs C. W. Hunt & Co. for the Lincoln

Wharf Power Station of the Boston Elevated Railway Co., which is remarkable for its enormous capacity. Bituminous coal is unloaded and raised to a height of 90 feet above the water level from the hatch of the vessel, and delivered to the stock pile or into overhead bunkers over mechanical stokers. The coal is unloaded at the rate of 320 tons per hour by one crane. The driving power is provided by an engine of 300 HP. which also drives the coal-breaking machinery that forms part of the plant, and is for the purpose of breaking the coal into suitable sizes for automatic stokers. The capacity of the coal-breaker is 5 tons per minute. The grab in use with this crane has a capacity of 2 tons with each lift, and the time occupied in raising the loaded grab to the overhead hopper is only six seconds. It is said that the whole cycle of unloading operations, including lowering the grab, running it out on the jib, opening it, filling it by its own action with 2 tons of coal, raising it again and discharging it, can be performed in twenty-two seconds. The crane is mounted on wheels so that it can be adjusted to the hatchway. The jib end of the crane is 40 feet long, so that the grab can be run out to a sufficient length to take the coal from the hold of the largest ships.

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